U.S. Army Center for Health Promotion and Preventive Medicine

USACHPPM

Epidemiological Consultation Report
No. 29-HE-2682a-00

# A Second Investigation of Injuries Among Officers Attending the U.S. Army War College, Carlisle Barracks, Pennsylvania, during Academic Year 2000





Readiness Thru Health

## *U.S. Army Center for Health Promotion and Preventive Medicine*

*The lineage of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) can be traced back over 50 years. This organization began as the U.S. Army Industrial Hygiene Laboratory, established during the industrial buildup for World War II, under the direct supervision of the Army Surgeon General. Its original location was at the Johns Hopkins School of Hygiene and Public Health. Its mission was to conduct occupational health surveys and investigations within the Department of Defense's (DOD's) industrial production base. It was staffed with three personnel and had a limited annual operating budget of three thousand dollars.*

*Most recently, it became internationally known as the U.S. Army Environmental Hygiene Agency (AEHA). Its mission expanded to support worldwide preventive medicine programs of the Army, DOD, and other Federal agencies as directed by the Army Medical Command or the Office of The Surgeon General, through consultations, support services, investigations, on-site visits, and training.*

*On 1 August 1994, AEHA was redesignated the U.S. Army Center for Health Promotion and Preventive Medicine with a provisional status and a commanding general officer. On 1 October 1995, the nonprovisional status was approved with a mission of providing preventive medicine and health promotion leadership, direction, and services for America's Army.*

*The organization's quest has always been one of excellence and the provision of quality service. Today, its goal is to be an established world-class center of excellence for achieving and maintaining a fit, healthy, and ready force. To achieve that end, the CHPPM holds firmly to its values which are steeped in rich military heritage:*

- ★ *Integrity is the foundation*
- ★ *Excellence is the standard*
- ★ *Customer satisfaction is the focus*
- ★ *Its people are the most valued resource*
- ★ *Continuous quality improvement is the pathway*

*This organization stands on the threshold of even greater challenges and responsibilities. It has been reorganized and reengineered to support the Army of the future. The CHPPM now has three direct support activities located in Fort Meade, Maryland; Fort McPherson, Georgia; and Fitzsimons Army Medical Center, Aurora, Colorado; to provide responsive regional health promotion and preventive medicine support across the U.S. There are also two CHPPM overseas commands in Landstuhl, Germany and Camp Zama, Japan who contribute to the success of CHPPM's increasing global mission. As CHPPM moves into the 21st Century, new programs relating to fitness, health promotion, wellness, and disease surveillance are being added. As always, CHPPM stands firm in its commitment to Army readiness. It is an organization proud of its fine history, yet equally excited about its challenging future.*

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
December 2000

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
A Second Investigation of Injuries Among Officers Attending the U.S. Army War College, Carlisle Barracks, Pennsylvania, during Academic Year 2000

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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and
U.S. Army and Physical Fitness Research Insitute, Army War College, Carlisle Barracks, PA

8. PERFORMING ORGANIZATION REPORT NUMBER
29-HE-2682a-00

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Center for Health Promotion and Preventive Medicine, Directorate of Epidemiology and Disease Surveillance, Aberdeen Proving Ground, MD 21010
and
U.S. Army and Physical Fitness Research Institute, Army War College, Carlisle Barracks, PA

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for Public Release, Distribution is Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
An epidemiological consultation (EPICON) was conducted to determine injury rates and causes of injuries among senior Army officers attending the U.S. Army War College (AWC) during Academic Year 2000 (AY00). A retrospective review of medical records was carried out and records were obtained on 228 of the 264 U.S. military students (86%). There were 623 visits to medical care providers with 52% of these for injury. There were 145 new injury cases (first visit for an injury) during the 10-month period making the injury rate 6.4 injuries /100 student months. The cumulative injury incidence (students with one or more injuries) during AY00 was 44%. This incidence was lower than the 56% incidence found in AY99 ($p<0.01$, risk ratio (AY99/AY00)=1.3, 95% confidence interval=1.1 to 1.5). Sport activity was associated with 40% of injuries in AY99 and 44% in AY00 (in AY99 47% of injuries were not linked to an activity, but in AY00 only 40% were not linked). Sport-specific percentages were as follows (AY99/AY00): softball 17%/16%, basketball 10%/8%, running 4%/5%, volleyball 4%/3%, and other sports 6%/10%. It is not clear why overall injury rates were lower in AY00, but there was command emphasis on injury reduction and injury control instruction and classes provided to students. Recommendations for on-going injury reduction include: 1) continue command emphasis on injury reduction; 2) continue instruction on injury control techniques, especially task-specific warm-up and sports-specific injury prevention; 3) for softball, emphasize the practice of allowing overrunning bases or use breakaway or compressive bases; 4) for volleyball, prohibit contact with the centerline at any time, provide training on blocking and spiking techniques, and assure continued play on wooden floors; 5) encourage the use of semi-rigid ankle braces to prevent ankle sprains, especially among those that have had prior ankle sprains; 6) reduce the number of practice sessions and games in sports activity; 7) continue to emphasize that medical care providers question students about what they were doing at the time of the injury and record this information in medical records.

14. SUBJECT TERMS
Sports, physical activity, Army Physical Fitness Test (APFT), cardiovascular risk, peak VO2, demographics, strength, blood lipids, warm-up, flexibility, military personnel, injury prevention

15. NUMBER OF PAGES
55

16. PRICE CODE

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | |

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# EPIDEMIOLOGICAL CONSULTATION NO. 29-HE-2682a-00 A SECOND INVESTIGATION OF INJURIES AMONG SENIOR OFFICERS ATTENDING THE U.S. ARMY WAR COLLEGE, CARLISLE BARRACKS, PENNSYLVANIA, DURING ACADEMIC YEAR 2000

## EXECUTIVE SUMMARY

1. INTRODUCTION. In April 1999, The Director, U.S. Army Physical Fitness Research Institute (APFRI), Carlisle Barracks, PA requested that the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) conduct an epidemiological consultation (EPICON) at the U.S. Army War College (AWC), Carlisle Barracks PA. This was in response to an estimated 66% increase in physical therapy consults compared to the previous year. The EPICON team found that the cumulative injury incidence (officers with one or more injuries) in AWC Academic Year 1999 (AY99) was 56%. During the next academic year, APFRI attempted to reduce injury incidence. The USACHPPM returned to the AWC in May 2000 to reexamine the incidence of injury. This report describes the injury rate and activities associated with injuries in AY00 and compares and contrasts the findings with AY99.

2. METHODS.

a. Medical records were reviewed retrospectively on U.S. military students and data on injuries and illnesses that occurred in the 10-month period the officers were in residence at the AWC were collected. Data on injuries were also collected for a 4-year period before the AWC. For each visit to a medical care provider, the following information was extracted: the date of the visit, activity associated with the injury (if available), diagnosis, anatomic location (injury only), and disposition. Informal interviews were conducted with medical personnel assigned to the AWC.

b. Additional data were obtained from AWC Student Operations, Army Physical Fitness Test (push-ups, sit-ups and 2 -mile run times) cards, a Health and Physical Fitness Assessment (HPFA), and three questionnaires. The HPFA was administered to students within 4 weeks of their arrival at the AWC and consisted of an evaluation of student's physical characteristics, aerobic capacity (peak $VO_2$), muscle strength, flexibility, body composition, blood pressure, and blood chemistry. The questionnaires addressed: 1) physical activity in the month prior to the AWC, 2) physical activity while in residence at the AWC, and 3) injuries while at the AWC.

3. FINDINGS. In AY00, medical records were obtained on 228 of the 264 U.S. military students in residence at the AWC (86%). The total number of visits to medical care providers was 623 with 52% of these for injury. Of the new injury visits, 43% were classified as overuse (assumed to be due to cumulative

microtrauma), 54% were classified as traumatic (assumed to be due to an acute event), and 1% was classified as environmental (insect bites). The most common injury diagnosis was muscle strains, accounting for 28% of all new injury cases. Upper body and lower body injuries accounted for 43% and 54%, respectively, of all new injuries. The knee, foot, low back, shoulder and ankle accounted for 14%, 11%, 9%, 8%, and 8%, respectively, of all new injury cases.

a. Where an activity could be associated with the injury, sports accounted for 44% of all new injury cases with sport-specific percentages as follows: softball 16%, basketball 8%, running 5%, weight lifting 4%, volleyball 3%, soccer 3%, and other sports 3%. Other activities (falls, moving furniture, motor vehicle accidents and striking objects), physical training, and environmental injuries (insect bites), accounted for 14%, 3%, and 1%, respectively, of activities associated with injuries. In 40% of cases, no proximate event was recorded with the injury in the medical record. The most common sport-related injuries were as follows: softball, 6 strains (4 hamstring strains), 7 contusions, and 3 fractures; basketball, 3 ankle sprains, 2 strains, and 3 fractures; running, 3 strains and 2 overuse injuries (not specified); volleyball, 2 sprains (finger and ankle), 1 calf strain, and 1 low back pain; weight lifting, 2 strains (upper arm and upper back), 1 overuse elbow injury, 1 wrist tendonitis, and 2 "pain" (not otherwise specified); soccer, 3 strains (wrist, ankle, calf), 1 finger fracture, and 1 chest contusion.

b. An injury in the 4-year period prior to attending the AWC was associated with a higher risk of another injury at the AWC (p=0.03). However, when specific injuries were examined, no single previous injury type was associated with a higher likelihood of experiencing that injury again at the AWC.

c. Compared to AY99, the number of new injuries, injury rates, and cumulative injury incidence were lower in AY00. In AY00 there were 145 new injury cases and the injury rate was 6.4 injuries/100 student-months; in AY99, there were 169 new injury cases and the injury rate was 7.3 injuries/100 student-months. The cumulative injury incidence was 44% in AY00 and 57% incidence in AY99 (p<0.01, risk ratio (AY99/AY00)=1.3, 95% confidence interval=1.1-1.6). The proportion of injuries associated with various sports and other causes was similar in AY00 and AY99 but the absolute number of injuries was lower in AY00.

4. DISCUSSION.

a. The injury incidence was 23% lower in AY00 compared to the previous year. The reasons for this are not clear. There was increased command emphasis on injury reduction and educational efforts by the APFRI during the academic year. These efforts began with information provided to students in their "welcome packets" prior to their arrival at the AWC, and efforts progressed throughout the year. At the student orientation, the commanding general and the APFRI director stressed the need for injury reduction. Injury issues were addressed with the seminar group leadership and class president at the start of AY00. Classes were provided to all seminar groups on aerobic conditioning,

strength training, spinal stabilization, and injury prevention during the fall and winter months. There were some small differences among the AY99 and AY00 students in terms of body mass and strength; however, these factors were not shown to be an injury risk factor in this study or previous studies.

b. The major organized sport activities at the AWC include softball, volleyball, and basketball. It is not surprising that these were the major identifiable activities associated with injury. Other studies of military populations indicated that sport-related activity may account for 19% to 51% of all injuries. In AY00 sports activity remains a target for injury reduction efforts, just as in AY99.

5. RECOMMENDATIONS.

a. Perform a task-specific warm-up before sports activity. This warm-up should duplicate the activities performed in the sport and should start slowly (low intensity, low force), building to a higher intensity over time. Also perform a task-specific warm-up when activity has ceased long enough to reduce body temperature (e.g., coming off the bench in volleyball or basketball) or for activity that is performed intermittently (e.g., batting or fielding activities in softball). This warm-up should again duplicate the activities in the sport.

b. Continue the command emphasis on injury reduction. Provide classroom instruction to students to inform them of the high rate of injury in AY99, common causes of sports injuries, appropriate warm-up procedures, and what to do when an injury occurs (to speed rehabilitation).

c. In softball, continue and emphasize the practice of allowing overrunning of second and third base. Use breakaway or compressive bases if sliding is allowed. Encourage players to periodically check the field when running after balls and to shout their intention to catch a ball so other players in the area know of their location. Assure padding of poles, backstops, field walls and other objects that players are likely to contact. Assure that softball fields are maintained to reduce the number of holes and rough spots in play areas.

d. Encourage the use of semi-rigid ankle braces to prevent ankle sprains, especially among those students that have had prior ankle sprains.

e. To reduce volleyball injuries, institute a rule change that prohibits contact with the centerline at any time, especially after the spike and block. Provide training on blocking and spiking techniques. Assure volleyball continues to be played on wooden floors rather than concrete or linoleum.

f. Reduce the number of practice sessions and games.

g. Continue to emphasize to medical care providers recording what students were doing at the time of injury to help identify targets for injury prevention.

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EPIDEMIOLOGICAL CONSULTATION NO. 29-HE-2682a-00
AN SECOND INVESTIGATION OF INJURIES AMONG SENIOR OFFICERS ATTENDING THE U.S. ARMY WAR COLLEGE, CARLISLE BARRACKS, PENNSYLVANIA, DURING ACADEMIC YEAR 2000

1. REFERENCES. Appendix A contains references used in this report.

2. INTRODUCTION.

a. In May 1999, the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) conducted an epidemiological consultation (EPICON) at the U.S. Army War College (AWC). This EPICON was prompted by an estimated 66% increase in physical therapy consults from August to April of 1999, compared to the same time the previous year. Screening of officer medical records showed that the overall incidence of injury during Academic Year 1999 (AY99) was twice as high as in Academic Year 1992 (AY92). AY92 was the last time a systematic examination of injuries at the AWC had been undertaken. The results of this EPICON and recommendations for reducing injuries were published (41).

b. During AY00, the staff of the Army Physical Fitness Research Institute (APFRI) increased awareness of the injury problem at the AWC and attempted to reduce injuries. In May 2000, USACHPPM personnel returned to conduct a second EPICON to see if the injury rate had changed. This report outlines the methods used to conduct the EPICON, the findings, and contrasts the injury rate in AY00 with that of AY99 and AY92.

3. BACKGROUND.

a. Officers attending the AWC spend most of their duty hours attending seminar group discussions, lectures, and participating in selected field trips. Officers are also involved in institutionally organized sports activities, which include softball, basketball, and volleyball. The average age of students is 43 years and most have served in the military for over 20 years. The officers tend to be much more physically active and have higher levels of physical fitness than other individuals of similar age (7, 37, 84, 85).

b. In AY92, the incidence of one or more injuries among 198 male officers was 28% during the 10 months of residence at the AWC (84). In AY99, injury incidence among male officers was 57%, twice as high as in AY92 ($p<0.01$, 95% confidence interval=1.6 to 2.6) (41). In AY99, an attempt was made to find the activities associated with the injuries. More than 40% of activities associated with injuries involved sports participation. In particular, softball (17%), basketball (10%), volleyball (4%), running (4%), and other sports

(6%) were implicated in the genesis of injuries. The actual proportion of injuries associated with sports was probably higher since in 47% of the cases an activity could not be linked to the injury.

4. PURPOSE. The purpose of the present study was to examine the incidence of injury in senior military officers at the AWC during AY00 and to compare and contrast injury information with historical data (AY92 and AY99). Activities associated with the injury and potential injury risk factors were also examined.

5. METHODS.

a. Subjects. The AY00 AWC resident class consisted of 337 individuals. There were 264 U.S. military students (78% of the class), 30 civilians (9% of the class) and 43 international fellows (13% of the class). Military students included 202 Army, 28 Air Force, 22 Navy, 11 Marines, and 1 Coast Guard personnel. Only the U.S. military students were examined in this study. Injury data was not available for the civilians since they did not obtain routine medical care in Army clinics and their medical records were not available. International fellows were officers from other nations who attended the AWC but who did not have complete medical records and often differed considerably from U.S. officers in terms of health and fitness. An early decision was made to exclude them from the study for these reasons.

b. Injury/illness Data. The Department of the Army (DA) Form 3444-6 (Medical Records) of military students were maintained at Dunham Army Health Clinic (DAHC) at Carlisle Barracks. These records were screened and for each visit to a medical care provider the date of visit, diagnosis, anatomic location (injury only), activity when injured (if available), and disposition were extracted. This information was typically available on one of three forms: DA 5181-R (Screening Note of Acute Medical Care), Standard Form (SF) 600 (Chronology of Medical Care), or SF 558 (Emergency Care and Treatment Form). The number of limited duty days was not extracted this year because experience last year indicated that this information was frequently missing from the medical record.

(1) Injury data were collected for two periods: while the student was at the AWC and the 4-year period before the AWC. Illness data was recorded only for the period students were at the AWC. Illness data were not included in this report except for a comparison with the total number of injury visits.

(2) An injury was defined as an event (presumably an energy exchange) that resulted in physical damage to the body (24) where the student visited a medical care provider and the encounter was documented in the medical record. Injuries could be due to overuse (long-term energy exchanges resulting in cumulative microtrauma), acute trauma (sudden energy exchanges

resulting in sudden, overload trauma), or environmental factors. Overuse injuries included musculoskeletal pain (not otherwise specified), stress fractures, tendonitis, bursitis, fasciitis, and overuse syndromes. Traumatic injuries included pain (not otherwise specified but from a traumatic event), strains, sprains, dislocations, fractures, abrasions, lacerations, and contusions. Environmental injuries included heat injuries, cold injuries, and insect bites.

(3) A new injury visit (or new injury) was defined as the first visit to a medical care provider for a specific injury. A follow-up injury visit (or follow-up injury) was a subsequent visit to a provider for the same injury.

c. Demographics. Gender and race were obtained from the medical records (most recent DA Form 88 (Report of Medical Examination)). Rank, branch of service, academic degree, marital status, geographic status and seminar group were obtained from records maintained in the AWC Student Operations Department. Geographic status was a combination of the student's martial status along with the location where they spent their off-duty time (e.g., a "road runner" left the local AWC area on weekends to go home at a more distant geographic location). The seminar group was the party of officers with which the individual participated in most academic and social activities.

d. Army Physical Fitness Test (APFT) Data. APFT data were obtained from the DA Form 705 (Army Physical Fitness Test Score Card). Raw scores for push-ups, sit-ups, and the 2-mile run were extracted. The push-up and sit-up performance measures were the maximum number that could be completed in separate 2 -minute periods. For the 2-mile run, time to complete the distance was the performance measure (2). The first diagnostic APFT was generally taken within the month of arrival at the AWC and the final test was taken about a month before departing the AWC. Only Army officers had APFT data (officers from other services took other tests that were not available).

e. Health and Physical Fitness Assessment (HPFA) Data. Within a month of arrival at the AWC, students could elect to participate in the HPFA conducted by U.S. APFRI . The assessment included 1) measures of physical characteristics, 2) measures of cardiovascular and physical fitness, 3) a blood chemistry (serum glucose and lipids) and, 4) a physical activity questionnaire. The Health Risk Appraisal (questionnaire) was not included in the HPFA this year (it was included in AY99). Each student was fully informed of the purposes and risks of the assessment, and if they chose to volunteer, they signed an informed consent statement approved by a U.S. Army Human Use Committee. The details of the HPFA are described below.

(1) Physical Characteristics. Age was obtained from date of birth. Stature was measured with an anthropometer and body mass with a beam scale. Students were in their stocking feet wearing T-shirts and gym shorts for the stature and body mass measurements. Body mass index (BMI) was calculated

as body mass/stature$^2$ (40). Waist circumference was measured with a flexible tape horizontal to the ground at the natural waist indentation (22). Hip circumference was measured across the largest diameter of the hip area with a flexible tape held horizontal to the ground. The waist to hip ratio (waist circumference/hip circumference) was calculated from these latter two measures.

(2) Cardiovascular and Physical Fitness Measures.

(a) Aerobic Capacity (Peak $VO_2$) and Maximal Heart Rate. Peak $VO_2$ was directly measured using a continuous uphill treadmill walking protocol. The treadmill speed was maintained at 3.3 miles/hr and the treadmill grade was increased 5% every 3 minutes until voluntary exhaustion. Expired gases were collected through a mouthpiece (with students wearing a nose clip) and analyzed for oxygen concentration on a Sensormedics 2900 Series Metabolic Cart (Sensormedics, Yorba Linda CA). A 12-lead electrocardiogram (ECG) was obtained using Marquette CASE 15 (Marquette Medical Systems, Milwaukee WI) and maximal heart rate was obtained from the highest heart rate value on the ECG.

(b) Muscle strength. Maximum voluntary strength was measured for knee extension, knee flexion, and the bench press using a one repetition maximum (1RM) procedure (38). Subjects began lifting a light mass, and the mass was progressively increased in a systematic manner. The increments in mass were determined by the effort displayed by the subject (acceleration of the mass, smoothness of movement, body stabilization, etc.). The procedure was continued until a mass was found that the subject could not lift. The last mass successfully lifted was recorded as the 1RM. At least a 30-second rest was given between lifts. Knee extension and knee flexion were evaluated with Cybex Leg Extension and Leg Flexion devices (Cybex Corporation, Ronkonkoma NY), respectively. The bench press was performed on a Universal Gym apparatus (Universal, West Palm Beach FL). The initial starting position for the bench press was higher relative to the chest than in AY99. The bench press to body mass ratio was calculated (bench press mass/body mass). Prior to the strength and flexibility tests, students performed a standard warm-up involving 5 minutes of moderate exercise on a cycle ergometer and 5 minutes of stretching. The leg press, measured in AY99, was not measured in AY00. It should be noted that the bench press starting position was higher relative to the chest (i.e., farther away from the chest) in AY00 compared to AY99.

(c) Flexibility. A general measure of hamstring flexibility was obtained using Wells' sit and reach test (68, 82). Subjects sat on the ground with their legs fully extended and their upper body at a 90$^\circ$ angle to their legs. With fully extended arms, they bent forward as far as possible and pushed on a sliding bar. The distance the subject was able to extend forward (hip flexion)

without bending at the knees was measured. A reference point (representing a value of zero) was set at the bottom of the feet.

(d) Body Composition. Body composition was assessed with three methods: dual energy X-ray absorptiometry (DEXA), bioelectrical impedance, and a circumferential technique. For the DEXA measurement, a LUNAR Model DPX-IQ (Madison, WI) system was used. With students in T-shirts and shorts (and with all metal objects removed), scanning began at the head and progressed in 1-cm slices to the feet. Scanning speed was 13 to 18 min for students with a body thickness <26 cm and 18 to 23 min for students with a body thickness of >26 cm. LUNAR software (version 4.6D or E) provided estimates of percent body fat (51). The bioelectric impedance technique used a RJL Systems device (RJL Systems, Clinton Township MI). The student was supine and electrodes were applied to the wrist and ankle. Percent body fat was estimated with the RJL proprietary algorithm. The circumferential technique used the standard U.S. Army circumference method (78). A flexible tape was used to measure abdominal and neck girths for men; hip, forearm, neck and wrist girths were determined for women (22). Height and weight were measured as above. Percent body fat was estimated from the equations of Vogel et al. (78).

(e) Systolic blood pressure, diastolic blood pressure, and resting heart rate were obtained with subjects seated quietly and comfortably. Values were recorded from a Dinamap Model 1846SX Vital Signs Monitor (Critikon, Tampa Bay FL) automated cuff. The standard instructions for use of the device were followed.

(3) Serum Glucose and Lipid Measures. Following a 12-hour fast, blood was withdrawn from an arm vein by venipuncture and analyzed for serum glucose, triglycerides, total cholesterol, low density lipoproteins, and high density lipoproteins (HDL). The cholesterol to HDL ratio (cholesterol/HDL) was calculated.

(4) Physical Activity Questionnaire. Officers were asked to complete a short questionnaire that asked them about the frequency of their exercise in the month prior to their arrival at the AWC. It also asked them for an overall rating of their physical activity compared to others of their age and sex (80). Appendix B contains the questionnaire.

f. Sports and Exercise Questionnaire. Near the end of AY00, officers were asked to complete a questionnaire that asked them about their participation in sports and exercise while they were at the AWC. This questionnaire was placed in student mailboxes during the month prior to graduation with instructions to complete and return it. Appendix C contains the questionnaire.

g. APFRI Health Assessment Survey. The APFRI staff administered this survey. Questions 16-19 addressed injuries and were analyzed as a part of this study.

h. Data Analysis. Data were analyzed using SPSS Version 10.0.5 and EPIINFO Version 6.04b.

(1) Descriptive statistics were compiled on types of injuries, anatomic location of injuries, and activities associated with the injury. Descriptive statistics were also calculated on demographics, APFT measures, HPFA variables, and questionnaires.

(2) Cumulative injury incidence was calculated as students with one or more injuries (numerator) divided by students with a medical record (denominator). In this calculation, environmental injuries were not included (i.e., only traumatic and overuse injuries were considered). The injury rate was calculated as the number of new injury visits (numerator) divided by the number of students with medical records times the number of months (denominator).

(3) Where frequency data were compared (number of cases), the Pearson chi-square statistic was used to test the hypothesis of no difference between groups; where expected cell sizes were less than 5, the Fischer Exact Test was used. Initial and final APFT scores were compared with the t-test.

(4) To examine risk factors for injury, cumulative injury incidence was compared at various levels of each potential risk factor using the Pearson chi-square statistic. Where variables were ordinal, Mantel-Haenszel chi-square for trend was employed. Continuous variables were split into 4 groups of similar size (based on the subject distribution of that variable). Questionnaire responses were collapsed to fewer groups (because of the small number of officers responding at the extremes) preserving symmetry around the central response categories.

(5) After completion of the univariate risk factor analysis, logistic regression was used to examine interrelationships and identify independent injury risk factors. All univariate risk factors with a chi-square of probability 0.20 or lower were included as independent variables in the analysis (28). The dependent variable was the presence or absence of injury. A backward stepwise selection procedure was used with the exit criteria set at $p \leq 0.10$. Each level of a potential risk factor was compared to a reference level (except the reference level itself) to obtain adjusted odds ratios. Confidence intervals were calculated from the estimated regression coefficients and their standard errors (28).

## 6. RESULTS

a. Total Visits for Medical Care. Medical records were obtained and reviewed on 228 of the 264 U.S. military students (86%). These 228 officers were defined as the cohort, and only these individuals were considered in the subsequent analyses. The total number of visits to medical care providers while at the AWC (both new visits and follow-up visits) was 623. Of these, 322 visits were for injury (52%) and 288 visits were for illness (46%). We could not classify 13 visits (2%) either because the student had a normal exam, the health care providers' handwriting could not be read, or because the diagnosis was not specified.

b. Injury Incidence and Injury Rate. Cumulative injury incidence (officers with one or more injuries) in this cohort was 43.9%. Cumulative incidence of overuse and traumatic injuries was 22.4% and 29.4%, respectively (an officer could have both types of injuries). There were 145 new injury cases during the 10-month period so the overall injury rate was 6.4 new injuries /100 student-months. Although there was a tendency for more men to be injured than women, there were no significant gender differences in injury incidence as shown in Table 1.

Table 1. Comparison of Injury Incidence in Men (n=213) and Women (n=15)

| Injury Category | Male Proportion Injured (%) | Female Proportion Injured (%) | p-value[a] |
|---|---|---|---|
| All Injuries | 44.6 | 33.3 | 0.40 |
| All Overuse Injuries | 23.0 | 13.3 | 0.39 |
| All Traumatic Injuries | 30.0 | 20.0 | 0.41 |

[a]From chi-square statistic

c. Injuries by Diagnosis. Table 2 shows the distribution of injuries by diagnosis. Of the new injury visits, 44% were classified as overuse, 55% were classified as traumatic, and 1% was environmental.

(1) Muscle strains accounted for 17% (n=24) of all new injuries. The most common anatomical sites for strains were the hamstrings (n=5) and calfs (n=4) with less than 2 cases each involving other regions. For hamstring strains, softball was involved in 3 cases and running in 2 cases. Volleyball, softball, soccer, and other sports (not specified) were involved in 1 case each.

(2) Sprains were involved in 10% (n=14) of the new injury cases and most of these (n=9) were ankle sprains.

(3) Fractures made up 8% (n=11) of the new injury cases with 5 involving the fingers, 2 involving the wrist, and 1 each involving the shoulder, chest (ribs), foot, and toe. Activities associated with the fractures included softball (n=3), basketball (n=2), soccer (n=1), and 5 cases where the activity was not in the medical record.

Table 2. Distribution of Injuries by Diagnosis

| Type | Diagnosis | New Injuries (N) | Follow-Ups (N) | Total (N) |
|---|---|---|---|---|
| OVERUSE | Pain (NOS[a]) | 21 | 27 | 48 |
| | Tendinitis | 9 | 10 | 19 |
| | Bursitis | 2 | 6 | 8 |
| | Fasciitis | 4 | 5 | 9 |
| | DJD[b] | 4 | 18 | 22 |
| | Overuse (NOS[a]) | 24 | 37 | 61 |
| TRAUMA | Pain (NOS[a]) | 4 | 2 | 6 |
| | Strain | 24 | 21 | 45 |
| | Sprain | 14 | 11 | 25 |
| | Fracture | 11 | 20 | 31 |
| | Contusion | 13 | 9 | 22 |
| | Abrasion/Laceration | 10 | 3 | 13 |
| | Trauma (NOS[a]) | 4 | 8 | 12 |
| | Insect Bite | 1 | 0 | 1 |
| Totals | | 145 | 177 | 322 |

[a]NOS=Not otherwise specified
[b]DJD=Degenerative joint disease

d. Injuries by Anatomic Location. Table 3 shows the distribution of injuries by anatomic location. Upper body and lower body injuries accounted for 43% and 54%, respectively, of all new injuries. The knee, foot, low back, shoulder and ankle accounted for 14%, 11%, 9%, 8%, and 8%, respectively, of all new injury visits. The proportion of follow-up visits for these body regions were 15%, 12%, 15%, 13%, and 11%, respectively.

e. Prior Injury. Table 4 shows the association of injuries experienced in the 4-year period prior to the AWC with injuries experienced at the AWC. Overall, officers with a prior injury were more likely to experience another injury while at the AWC. However, when various injury categories (overuse or traumatic) or types of injuries were examined, there were no significant differences among those with and those without prior injuries. There was a trend for those with prior injuries to have both more overuse and more traumatic injuries.

Table 3. Distribution of Injuries by Anatomic Location

| Body Area | Body Part | New Injury Visits (N) | Follow Up Injury Visits (N) | Total Injury Visits (N) |
|---|---|---|---|---|
| UPPER BODY | Head/Face | 9 | 2 | 11 |
| | Neck | 2 | 0 | 2 |
| | Chest | 9 | 2 | 11 |
| | Abdomen | 3 | 0 | 3 |
| | Upper Back | 1 | 2 | 3 |
| | Shoulders | 12 | 23 | 35 |
| | Arms/Elbows | 8 | 6 | 14 |
| | Wrist | 4 | 11 | 15 |
| | Hand | 5 | 0 | 5 |
| | Fingers | 10 | 3 | 13 |
| LOWER BODY | Lower Back | 13 | 26 | 39 |
| | Pelvis/Hips | 1 | 10 | 11 |
| | Thigh | 9 | 17 | 26 |
| | Knee | 21 | 26 | 47 |
| | Calf | 4 | 2 | 6 |
| | Shin | 1 | 3 | 4 |
| | Ankle | 12 | 19 | 31 |
| | Foot | 16 | 21 | 37 |
| | Toe | 1 | 2 | 3 |
| | Multiple | 4 | 2 | 6 |
| | Total | 145 | 177 | 322 |

Table 4. Association of Prior Injuries (4 Years Before AWC) with Injuries Experienced at the AWC

| Injury or Injury Category | Prior Injury | | No Prior Injury | | p-value[a] |
|---|---|---|---|---|---|
| | N | Injured at AWC (%) | N | Injured at AWC (%) | |
| Overall (any injury) | 137 | 49.6 | 91 | 35.2 | 0.03 |
| All Overuse Injuries | 88 | 27.3 | 140 | 19.3 | 0.16 |
| All Traumatic Injuries | 86 | 33.7 | 142 | 26.8 | 0.26 |
| Strains | 36 | 11.1 | 192 | 10.4 | 0.90 |
| Sprains | 23 | 4.3 | 205 | 6.3 | 0.70 |
| Overuse (NOS)[b] | 32 | 15.6 | 196 | 9.7 | 0.31 |
| Pain (NOS)[b] | 46 | 15.2 | 182 | 7.7 | 0.11 |
| Fractures | 16 | 0 | 212 | 5.0 | 0.35 |

[a]From chi-square statistic
[b]NOS=Not otherwise specified

f. Activities Associated with Injuries. Table 5 shows the activity associated with the new injury cases.

(1) In 40% of the cases (58/145), an activity was not listed in the medical record. Sport or exercise activity was associated with 45% of all new injury cases (65/145). Among the sports, softball had the highest incidence of association with new injuries followed by basketball, running, weight lifting, soccer, and volleyball, respectively. The category "other sports" included the

following notations in the medical records: “sports”, “kicked during sports”, “Jim Thorpe Day sports”, and “injured during sporting activity”. “Other activities” included falls (walking, going down stairs, or not specified), moving furniture, motor vehicle accidents, and striking objects. The “environmental” category was for the injury associated with the insect.

(2) Injuries by sport were as follows. Softball injuries included 6 strains (3 hamstrings, 2 calf, and 1 abdomen), 7 contusions, 3 fractures (wrist, rib, and shoulder), 2 abrasions/lacerations, 2 overuse knee injuries, 1 ankle sprain, 1 shoulder tendonitis, and 1 shoulder pain (NOS). Basketball injuries included 3 ankle sprains, 2 strains (shin and neck), 2 fractures (foot and finger), 2 face abrasion/laceration, 2 overuse injuries (finger and knee), and 1 knee tendonitis. Running injuries involved 3 strains (2 hamstring), 2 overuse knee injuries, 1 ankle sprain, and 1 foot pain (NOS). Volleyball injuries included 2 sprains (finger and ankle), 1 calf strain, and 1 low back pain. Weight lifting injuries included 2 strains (upper arm and upper back), 1 overuse elbow injury, 1 wrist tendonitis, and 2 NOS pain (low back and chest). Soccer injuries included 3 strains (wrist, ankle, and calf), 1 finger fracture, and 1 chest contusion.

Table 5. Activities Associated With New Injuries

| Activity | Total (N) | Proportion of Total (%) |
|---|---|---|
| Softball | 23 | 15.9 |
| Basketball | 12 | 8.3 |
| Running | 7 | 4.8 |
| Volleyball | 4 | 2.8 |
| Weight Lifting | 6 | 4.1 |
| Soccer | 5 | 3.4 |
| Other Sports | 4 | 2.8 |
| Physical Training | 4 | 2.8 |
| Other Activities | 21 | 14.4 |
| Environmental | 1 | 0.7 |
| Unknown | 58 | 40.0 |

g. Descriptive Data: Demographics, APFT Data, HPFA, Questionnaires

(1) Demographics. Table 6 shows descriptive information on cohort demographics. Most officers were male, white, married, Army LTC (or equivalent) with Master’s degrees.

(2) APFT Data. Table 7 shows descriptive data on the APFT raw scores and a comparison of the initial and final tests. Men and women were considered separately because of the different criteria for passing the test (2) and because of the large differences in scores between men and women. Paired t-tests demonstrated that there were no significant differences between the initial and final scores on any of the test events for either gender. The correlation coefficients (r-values) comparing the pre- and post-scores were high, suggesting that individuals had similar scores on both tests.

Table 6. Demographics of the Cohort

| Variable | Descriptors for Variable | N | Proportion (% of total within variable) |
|---|---|---|---|
| Gender | Male | 213 | 93.4 |
| | Female | 15 | 6.6 |
| Rank | LTC or CDR[a] | 172 | 75.4 |
| | COL or CAPT[b] | 56 | 24.6 |
| Branch | Army | 184 | 80.7 |
| | Navy | 13 | 5.7 |
| | Air Force | 21 | 9.2 |
| | Marines | 9 | 3.9 |
| | Coast Guard | 1 | 0.4 |
| Academic Degree | Bachelors | 54 | 23.7 |
| | Masters | 160 | 70.2 |
| | Doctorate, Law, Medical | 12 | 5.3 |
| | Unknown (Missing from database) | 2 | 0.9 |
| Race | White | 193 | 84.6 |
| | Black | 25 | 11.0 |
| | Hispanic | 4 | 1.8 |
| | Other | 6 | 2.6 |
| Martial Status | Married | 215 | 94.3 |
| | Not Married | 13 | 5.7 |
| Geographic Status | Road Runner[c] | 22 | 9.6 |
| | Geographic Bachelor[d] | 14 | 6.1 |
| | Bachelor in Residence | 5 | 2.2 |
| | Family in Residence | 187 | 82.0 |

[a]LTC=Lieutenant Colonel (Army, Air Force or Marines), CDR=Commander (Navy)
[b]COL=Colonel (Army, Navy or Marines), CAPT=Captain (Navy)
[c]Road Runner=Left local AWC area to return to house at a more distant geographic location during off-duty (primarily weekends)
[d]Geographic Bachelor=At AWC without spouse

(3) HPFA Data. Table 8 shows the descriptive data on the HPFA. Men and women were separated because of the large differences between the genders on many of these measures. There were 206 officers (90% of the cohort) that completed at least some portion of the HPFA.

(4) Physical Activity Questionnaire (Prior to the AWC). There were 218 officers (96% of the cohort) that completed the questionnaire on physical activity in the month prior to the AWC (Appendix B). Student responses to this questionnaire are shown in Table 9. The proportion of officers reporting that they were active at least 1-2 days per week was 95%, 69%, 49%, and 56% for aerobic exercise, weight training, sports, and walking or hiking, respectively. The fifth question on the questionnaire (not shown in Table 9) asked officers to rate their physical activity compared to others of their age and sex (80). On this question, the number of individuals rating themselves as 1) much more active, 2) somewhat more active, 3) about the same, 4) somewhat less active, and 5) much less active were 29 (13%), 96 (44%), 61 (28%), 24 (11%), and 6 (3%), respectively.

Table 7. Comparison of Initial and Final APFT Scores

| Gender | Event | N | Initial (M±SD reps or mins) | Final (M±SD reps or mins) | p-value[a] | r-value[b] |
|---|---|---|---|---|---|---|
| Men | Push-Ups | 138 | 56±14 | 57±13 | 0.25 | 0.87 |
| | Sit-Ups | 137 | 62±13 | 63±14 | 0.42 | 0.86 |
| | 2-Mile Run | 133 | 15.4±1.4 | 15.4±1.5 | 0.93 | 0.85 |
| Women | Push-Ups | 10 | 39±14 | 39±15 | 0.71 | 0.96 |
| | Sit-Ups | 10 | 66±12 | 67±12 | 0.49 | 0.85 |
| | 2-Mile Run | 10 | 17.5±1.5 | 17.8±2.3 | 0.36 | 0.87 |

[a]From paired t-test comparing initial and final scores
[b]Correlation coefficient comparing initial and final scores

Table 8. HPFA Data

| Variable | Men | | Women | |
|---|---|---|---|---|
| | N | Mean±SD | N | Mean±SD |
| Age (Yrs) | 192 | 43.5±2.8 | 13 | 44.2±2.7 |
| Stature (in) | 193 | 71.1±2.7 | 13 | 64.7±4.1 |
| Body Mass (lbs) | 193 | 192.6±24.0 | 13 | 141.0±26.8 |
| Body Mass Index (kg/m$^2$) | 193 | 26.7±2.4 | 13 | 23.5±2. |
| Waist Circumference (in) | 193 | 36.0±2.7 | 13 | 28.9±3.0 |
| Hip Circumference (in) | 193 | 40.1±2.3 | 13 | 37.9±2.8 |
| Waist/Hip Ratio | 193 | 0.90±0.05 | 13 | 0.76±0.04 |
| Peak $VO_2$ (ml/kg/min) | 178 | 45.4±5.7 | 13 | 41.9±6.2 |
| Max Heart Rate (beat/min) | 178 | 183±11 | 13 | 183±13 |
| Bench Press Strength (lbs) | 191 | 213±43 | 13 | 116±31 |
| Bench Press/Body Mass Ratio | 191 | 1.12±0.23 | 13 | 0.82±0.14 |
| Knee Extension Strength (lbs) | 188 | 204±36 | 13 | 135±36 |
| Knee Flexion Strength (lbs) | 185 | 145±29 | 13 | 90±24 |
| Body Fat (%) (DEXA) | 193 | 23.5±4.2 | 13 | 30.0±7.6 |
| Body Fat (%) (Bioelectric Impedance) | 193 | 19.3±4.4 | 10 | 22.9±7.4 |
| Body Fat (%) (Circumference) | 193 | 20.9±3.5 | 12 | 27.4±5.2 |
| Sit and Reach Flexibility (cm) | 191 | 32±9 | 13 | 35±7 |
| Resting Heart Rate (beat/min) | 192 | 68±11 | 13 | 63±7 |
| SBP (mmHG) | 192 | 126±12 | 13 | 116±12 |
| DBP (mmHG) | 192 | 75±8 | 13 | 67±8 |
| Glucose (mg/dl) | 193 | 95±9 | 12 | 89±5 |
| Triglycerides (mg/dl) | 192 | 131±70 | 12 | 65±20 |
| Cholesterol (mg/dl) | 193 | 206±35 | 12 | 174±21 |
| HDL (mg/dl) | 190 | 45±11 | 12 | 63±10 |
| LDL (mg/dl) | 190 | 135±34 | 12 | 98±21 |
| Cholesterol/HDL Ratio | 190 | 4.83±1.49 | 12 | 2.82±0.58 |

Table 9. Self Reported Physical Activity in the Month Prior to Arrival at the AWC (Values are the Numbers of Officers Responding in Each Category)

| | None | <1/wk | 1-2 days/wk | 3-4 days/wk | 5-6 days/wk | 7 days/wk |
|---|---|---|---|---|---|---|
| Aerobic Exercise | 7 | 14 | 46 | 100 | 47 | 4 |
| Strength Training | 53 | 14 | 69 | 69 | 12 | 1 |
| Sports Activity | 81 | 30 | 67 | 36 | 2 | 2 |
| Walking or Hiking | 58 | 37 | 71 | 30 | 12 | 9 |

(5) Sport and Exercise Activity Questionnaire (While at the AWC). Only 88 officers (39% of the cohort) returned the questionnaire regarding sports and exercise activity at the AWC (Appendix C). Table 10 shows the number of officers responding to each question. Seventy-two percent of responding officers participated in over 95% of the softball games and practices. Fifty-six and 34% did not participate at all in basketball and volleyball, respectively. Twenty-five percent and 42% participated in over 95% of basketball and volleyball games and practices, respectively. The percentage of officers who reported performing aerobic and strength training at least 1-2 times per week was 94% and 77%, respectively.

Table 10. Self Reported Sport and Exercise Activity While at the AWC (Values are the Numbers of Officers Responding in Each Category)

| | Proportion of Participation in Games and Practices | | | | | |
|---|---|---|---|---|---|---|
| Sport | None | 1-24% | 25-49% | 50-75% | 75-95% | 96-100% |
| Softball | 3 | 9 | 3 | 2 | 8 | 63 |
| Basketball | 51 | 5 | 0 | 2 | 7 | 22 |
| Volleyball | 30 | 5 | 1 | 2 | 13 | 37 |
| | Average Participation (Days/Week) | | | | | |
| Exercise | 0 | <1 | 1-2 | 3-4 | 5-6 | 7 |
| Aerobic Training | 0 | 5 | 8 | 52 | 20 | 3 |
| Strength Training | 1 | 19 | 28 | 34 | 6 | 0 |

(6) APFRI Health Assessment Survey. Only 79 officers (35% of the cohort) returned the APFRI Health Assessment Survey. Responses to Questions 16,18, and 19 are shown in Table 11. Of the people who sought medical advice for their injury (n=22), 16 (73%) responded that they had consulted a physical therapist, 14 (64%) had consulted their primary care physician, 17 (77%) had gone to sick call, and 9 (41%) reported that they had consulted a specialist. Of the people who sought medical advice for their injury (n=22), 6 (27%) consulted 1 source, 5 (23%) consulted 2 sources, 3 (14%) consulted 3 sources, and 6 (27%) consulted all 4 sources. Responses to Question 17 (which asked officers to list their injuries) were highly varied and some were difficult to put into categories. Responses included "muscle pulls",

"injured finger in softball", "knee", and "trauma, left thigh". Among the 42 replies were 8 ankle sprains, 7 hamstring strains, 4 quadriceps strains, and 4 fractures.

Table 11. Responses to the APFRI Health Assessment Survey

| Question | No (N) | Yes (N) | NA[a] | Yes (%) |
|---|---|---|---|---|
| 16. Experienced Injury | 37 | 42 | 0 | 53.2 |
| 18. Sought Medical Advice | 22 | 20 | 37 | 48.6 |
| 19. Injury Prevented Participation | 11 | 31 | 37 | 73.8 |

[a] Not Applicable (i.e., not injured)

g. Univariate Risk Factor Evaluation. Risk factor analysis was carried out on men only. This was because of the small number of women (n=15) and the large gender differences in many of the measurements.

(1) Demographics. Table 12 shows that rank and seminar group were associated with injuries. COLs or CAPTs were less likely to be injured than LTCs or CDRs. Seminar groups 1, 4, and 12 tended to have a lower injury incidence than other seminar groups.

(2) APFT Variables. Table 13 shows that there were 147 male Army officers in the cohort for which APFT scores were obtained. In this group, injury incidence was not related to push-ups, sit-ups, or 2-mile run times on either the initial or final test.

(3) Physical Characteristics. Table 14 shows the association of physical characteristics and injury incidence. None of these variables were significantly associated with injuries. There was a very slight tendency for older officers to be injured less than younger officers.

(4) Cardiorespiratory and Fitness Measures. Table 15 shows the association between injury incidence and the cardiorespiratory and fitness measures. The bench press/body mass ratio showed a very weak relationship with injury incidence. None of the other variables were associated with injury incidence.

Table 12. Association Between Injury Incidence and Demographic Characteristics (Men Only)

| Variable | Category | N | Injury Incidence (%) | Chi-Square p-value |
|---|---|---|---|---|
| Rank | LTC or CDR[a] | 160 | 49.4 | 0.02 |
| | COL or CAPT[b] | 53 | 30.2 | |
| Branch | Army | 172 | 44.2 | 0.94 |
| | Navy | 12 | 41.7 | |
| | Air Force | 20 | 50.0 | |
| | Marines | 8 | 50.0 | |
| | Coast Guard | 1 | 0 | |
| Academic Degree | Bachelor's | 53 | 41.5 | 0.84 |
| | Master's | 147 | 46.3 | |
| | Doctoral, Law, Medical | 11 | 45.5 | |
| Race | White | 181 | 43.6 | 0.88 |
| | Black | 23 | 52.2 | |
| | Hispanic | 4 | 50.0 | |
| | Other | 5 | 40.0 | |
| Marital Status | Married | 204 | 44.6 | 0.99 |
| | Not Married | 9 | 44.4 | |
| Seminar Group | 1 | 10 | 10.0 | 0.06 |
| | 2 | 9 | 55.6 | |
| | 3 | 10 | 60.0 | |
| | 4 | 11 | 9.1 | |
| | 5 | 10 | 40.0 | |
| | 6 | 12 | 58.3 | |
| | 7 | 11 | 54.5 | |
| | 8 | 11 | 63.6 | |
| | 9 | 12 | 50.0 | |
| | 10 | 12 | 58.3 | |
| | 11 | 12 | 58.3 | |
| | 12 | 11 | 9.1 | |
| | 13 | 11 | 27.3 | |
| | 14 | 12 | 25.0 | |
| | 15 | 11 | 63.6 | |
| | 16 | 11 | 54.5 | |
| | 17 | 7 | 28.6 | |
| | 18 | 10 | 60.0 | |
| | 19 | 10 | 50.0 | |
| | 20 | 10 | 50.0 | |

[a]LTC=Lieutenant Colonel (Army, Air Force or Marines), CDR=Commander (Navy)
[b]COL=Colonel (Army, Navy or Marines), CAPT=Captain (Navy)

Table 13. Association Between Injury Incidence and Army Physical Fitness Test (APFT) Data (Men Only)

| Variable | Category | N | Injury Incidence | Chi-Square p-value (Overall / Trend) |
|---|---|---|---|---|
| Initial Push-Ups | 30-45 (repetitions) | 37 | 32.4 | 0.14 / 0.37 |
| | 46-59 | 39 | 48.7 | |
| | 60-66 | 35 | 28.6 | |
| | 67-107 | 36 | 50.0 | |
| Initial Sit-Ups | 32-50(repetitions) | 43 | 34.9 | 0.32 / 0.43 |
| | 51-64 | 30 | 46.7 | |
| | 65-74 | 36 | 30.6 | |
| | 75-100 | 37 | 48.6 | |
| Initial 2-Mile Run | 11.25-14.27(min) | 35 | 34.3 | 0.72 / 0.96 |
| | 14.28-15.47 | 36 | 44.4 | |
| | 15.48-16.50 | 35 | 42.9 | |
| | 16.51-18.58 | 35 | 34.4 | |
| Final Push-Ups | 32-45(repetitions) | 38 | 39.5 | 0.27 / 0.72 |
| | 46-59 | 34 | 44.1 | |
| | 60-66 | 39 | 28.2 | |
| | 67-95 | 34 | 50.0 | |
| Final Sit-Ups | 30-50 (repetitions) | 39 | 38.5 | 0.57 / 0.51 |
| | 51-66 | 35 | 40.0 | |
| | 67-73 | 34 | 32.4 | |
| | 74-100 | 37 | 48.6 | |
| Final 2-Mile Run | 12.60-14.22 (min) | 32 | 37.5 | 0.98 / 0.71 |
| | 14.23-15.37 | 36 | 36.1 | |
| | 15.38-16.52 | 36 | 38.9 | |
| | 16.53-19.30 | 34 | 41.2 | |

Table 14. Association Between Injury Incidence and Physical Characteristics (Men Only)

| Variable | Category | N | Injury Incidence (%) | Chi-Square p-value (Overall / Trend) |
|---|---|---|---|---|
| Age | 37-40 (yrs) | 18 | 55.6 | 0.31 / 0.13 |
| | 41-45 | 141 | 44.7 | |
| | 46-55 | 35 | 34.3 | |
| Stature | 64.75-69.00 (in) | 48 | 50.0 | 0.55 / 0.88 |
| | 69.01-71.25 | 56 | 37.5 | |
| | 71.26-73.00 | 47 | 40.4 | |
| | 73.01-78.25 | 42 | 47.6 | |
| Body Mass | 134-174 lbs | 48 | 39.6 | 0.85 / 0.94 |
| | 175-192 | 50 | 48.0 | |
| | 193-208 | 45 | 44.4 | |
| | 209-262 | 48 | 41.7 | |
| Body Mass Index | 18.68-25.31 ($kg/m^2$) | 48 | 33.3 | 0.39 / 0.28 |
| | 25.32-26.85 | 50 | 48.0 | |
| | 26.66-28.24 | 47 | 48.9 | |
| | 28.25-33.53 | 47 | 44.7 | |
| Waist Circumference | 28.25-33.75 in | 48 | 35.4 | 0.14 / 0.81 |
| | 33.76-36.00 | 54 | 55.6 | |
| | 36.01-37.75 | 44 | 36.4 | |
| | 37.76-42.25 | 47 | 44.7 | |
| Hip Circumference | 34.25-38.25 in | 47 | 44.7 | 0.60 / 0.46 |
| | 38.26-40.00 | 52 | 46.2 | |
| | 40.01-41.75 | 47 | 48.9 | |
| | 41.76-45.25 | 45 | 35.6 | |
| Waist/Hip Ratio | 0.769-0.869 | 49 | 38.8 | 0.83 / 0.62 |
| | 0.870-0.894 | 46 | 47.8 | |
| | 0.895-0.930 | 46 | 45.7 | |
| | 0.931-1.019 | 47 | 44.7 | |

Table 15. Association Between Injury Incidence and the Cardiorespiratory and Fitness Variables (Men Only)

| Variables | Ranges | N | Injury Incidence (%) | Chi-Square p-value (Overall / Trend) |
|---|---|---|---|---|
| Peak $VO_2$ | 32.4-41.9 ml/kg/min | 44 | 38.6 | 0.47 / 0.58 |
| | 42.2-45.0 | 45 | 37.6 | |
| | 44.1-48.8 | 44 | 52.3 | |
| | 48.9-63.9 | 45 | 40.0 | |
| Maximal Heart Rate | 150-176 beats/min | 43 | 32.6 | 0.52 / 0.19 |
| | 177-182 | 44 | 43.2 | |
| | 183-191 | 48 | 45.8 | |
| | 192-214 | 43 | 46.5 | |
| Bench Press Strength | 115-180 lbs | 57 | 58.5 | 0.24 / 0.16 |
| | 181-215 | 55 | 61.2 | |
| | 216-245 | 45 | 51.9 | |
| | 246-355 | 34 | 48.9 | |
| Bench Press/Body Mass Ratio | 0.627-0.964 | 46 | 28.3 | 0.10 / 0.07 |
| | 0.965-1.086 | 47 | 51.1 | |
| | 1.087-1.247 | 46 | 45.7 | |
| | 1.248-1.919 | 48 | 50.0 | |
| Knee Extension Strength | 96-168 lbs | 39 | 46.2 | 0.92 / 0.86 |
| | 169-204 | 53 | 41.5 | |
| | 205-228 | 27 | 40.7 | |
| | 229-240 | 69 | 46.4 | |
| Knee Flexion Strength | 60-120 lbs | 47 | 40.4 | 0.77 / 0.77 |
| | 121-144 | 59 | 42.4 | |
| | 145-168 | 53 | 49.1 | |
| | 169-216 | 26 | 38.5 | |
| Body Fat (DEXA) | 10.6-20.7 % | 47 | 46.8 | 0.64 / 0.52 |
| | 20.8-23.7 | 43 | 41.9 | |
| | 23.8-26.3 | 44 | 50.0 | |
| | 26.4-36.0 | 48 | 37.5 | |
| Body Fat (Bioelectric Impedance) | 5-15% | 41 | 43.9 | 0.48 / 0.28 |
| | 16-19 | 53 | 50.9 | |
| | 20-22 | 51 | 43.1 | |
| | 23-30 | 48 | 35.4 | |
| Body Fat (Circumference) | 9.4-18.8 % | 47 | 40.4 | 0.55 / 0.79 |
| | 18.9-21.0 | 48 | 45.8 | |
| | 21.1-23.3 | 48 | 50.0 | |
| | 23.4-29.0 | 47 | 36.2 | |

| | | | | |
|---|---|---|---|---|
| Sit and Reach Flexibility | 6.0-26.0 cm | 48 | 31.3 | 0.18 / 0.26 |
| | 26.1-32.0 | 47 | 53.2 | |
| | 32.1-38.5 | 52 | 46.2 | |
| | 38.6-54.0 | 44 | 45.5 | |
| Resting Heart Rate | 46-60 beats/min | 48 | 41.7 | 0.90 / 0.50 |
| | 61-68 | 57 | 42.1 | |
| | 69-75 | 44 | 43.2 | |
| | 76-104 | 43 | 48.8 | |
| Systolic Blood Pressure | 100-117 mmHg | 53 | 45.3 | 0.79 / 0.91 |
| | 118-127 | 44 | 45.5 | |
| | 128-135 | 48 | 37.5 | |
| | 136-168 | 47 | 46.8 | |
| Diastolic Blood Pressure | 53-71 mmHg | 54 | 40.7 | 0.83 / 0.38 |
| | 72-75 | 49 | 40.8 | |
| | 76-80 | 50 | 46.0 | |
| | 81-93 | 39 | 48.7 | |

(5) Glucose and Lipid Measures. Table 16 shows that neither serum glucose nor any of the lipid measures were associated with injury incidence.

(6) Physical Activity Questionnaire (Prior to the AWC). Table 17 shows the association between injury incidence and the responses to the Physical Activity Questionnaire. Sports activity in the month prior to the AWC was associated with a higher injury incidence while at the AWC.

(7) Sport and Exercise Activity While at the AWC. The association between injury incidence and responses on the Sport and Exercise Activity Questionnaire is shown in Table 18. None of the questionnaire variables were associated with injury incidence.

Table 16. Association Between Injury Incidence and Serum Glucose and Lipid Measurements (Men Only)

| Variable | Ranges | N | Injury Incidence (%) | Chi-Square p-value (Overall/Trend) |
|---|---|---|---|---|
| Glucose | 74-88mg/dl | 50 | 42.0 | 0.59 / 0.28 |
| | 89-94 | 49 | 38.8 | |
| | 95-99 | 46 | 43.5 | |
| | 100-127 | 48 | 52.1 | |
| Triglycerides | 43-84 mg/dl | 46 | 50.0 | 0.79 / 0.61 |
| | 85-113 | 50 | 40.0 | |
| | 114-157 | 49 | 44.9 | |
| | 158-512 | 47 | 42.6 | |
| Cholesterol | 130-180 mg/dl | 49 | 36.7 | 0.12 / 0.60 |
| | 181-204 | 50 | 44.0 | |
| | 205-224 | 46 | 58.7 | |
| | 225-354 | 48 | 37.5 | |
| High Density Lipoprotein (HDL) | 25-37 mg/dl | 49 | 36.7 | 0.30 / 0.40 |
| | 38-43 | 44 | 43.2 | |
| | 44-51 | 51 | 54.9 | |
| | 52-100 | 46 | 41.3 | |
| Low Density Lipoprotein (LDL) | 57-110 mg/dl | 47 | 38.3 | 0.31 / 0.39 |
| | 111-130 | 48 | 41.7 | |
| | 131-154 | 47 | 55.3 | |
| | 155-293 | 48 | 41.7 | |
| Cholesterol/ HDL Ratio | 1.92-3.88 | 46 | 41.3 | 0.41 / 0.58 |
| | 3.89-4.54 | 47 | 48.9 | |
| | 4.55-5.54 | 48 | 50.0 | |
| | 5.55-12.21 | 46 | 34.8 | |

Table 17. Association Between Injury Incidence and Self-Reported Physical Activity in the Month Prior to the AWC (Men Only)

| Question | Response Categories | N | Injury Incidence (%) | Chi-Square p-value (Overall / Trend) |
|---|---|---|---|---|
| 1. Aerobic Exercise | <1 day/wk | 20 | 30.0 | 0.37 / 0.94 |
| | 1-2 days/wk | 42 | 52.4 | |
| | 3-4 days/wk | 94 | 45.7 | |
| | ≥5 days/wk | 47 | 40.4 | |
| 2. Strength Training | <1 day/wk | 62 | 37.1 | 0.59 / 0.29 |
| | 1-2 days/wk | 67 | 47.8 | |
| | 3-4 days/wk | 63 | 47.6 | |
| | ≥5 days/wk | 11 | 45.5 | |
| 3. Sports Activity | <1 day/wk | 101 | 41.6 | 0.04 / <0.01 |
| | 1-2 days/wk | 64 | 35.9 | |
| | 3-4 days/wk | 34 | 64.7 | |
| | ≥5 days/wk | 3 | 66.7 | |
| 4. Walking or Hiking | <1 day/wk | 88 | 48.9 | 0.64 / 0.21 |
| | 1-2 days/wk | 67 | 41.8 | |
| | 3-4 days/wk | 30 | 40.0 | |
| | ≥5 days/wk | 17 | 35.3 | |
| 5. Overall Physical Activity | More active | 113 | 42.5 | 0.92 / 0.73 |
| | About the same | 59 | 45.8 | |
| | Less active | 29 | 44.4 | |

Table 18. Association Between Injury Incidence and Self-Reported Participation in Sports and Exercise While Attending the AWC (Men Only)

| Question | Response Categories | N | Injury Incidence (%) | Chi-Square p-value (Overall / Trend) |
|---|---|---|---|---|
| 1. Softball | 0-24% of time | 7 | 71.4 | 0.21 / 0.72 |
| | 25-95% of time | 13 | 30.8 | |
| | 96-100% of time | 61 | 42.6 | |
| 2. Basketball | 0-24% of time | 50 | 36.0 | 0.63 / 0.35 |
| | 25-95% of time | 9 | 44.4 | |
| | 96-100% of time | 21 | 47.6 | |
| 3. Volleyball | 0-24% of time | 33 | 45.5 | 0.77 / 0.49 |
| | 25-95% of time | 13 | 38.5 | |
| | 96-100% of time | 35 | 37.1 | |
| 4. Aerobic Exercise | 0-2 days/wk | 11 | 27.3 | 0.60 / 0.58 |
| | 3-4 days/wk | 48 | 43.8 | |
| | ≥5 days/wk | 22 | 40.9 | |
| 5. Strength Training | 0-2 days/wk | 44 | 31.8 | 0.18 / 0.15 |
| | 3-4 days/wk | 32 | 53.1 | |
| | ≥5 days/wk | 5 | 40.0 | |

i. Multivariate Analysis of Injury Risk Factors

(1) Few variables reached the ad hoc criterion (univariate chi-square p-value < 0.20) for consideration in the backward stepping logistic regression analysis. These variables were rank, age, initial push-ups, waist circumference, maximal heart rate, bench press, bench press/body mass ratio, sit-and-reach flexibility, cholesterol, and sports activity in the month prior to the AWC. Because of the high correlation between bench press strength and the bench press/body mass ration (r=0.81) only the latter was included in the regression. Also, on the question on sports activity in the month prior to the AWC, the final response category (≥5 days/wk) was collapsed into the prior response category (3-4 days/wk) because of the small number of subjects in the final category (n=3). The continuous variables age, initial push-ups, maximal heart rate, bench press/body mass ratio, sit-and-reach flexibility, and cholesterol were entered as quartiles (categorical variables).

(2) Logistic regression requires complete data on an individual for that individual to be included in the analysis. Only 147 men had initial push-up data. When initial push-up was not included in the first model, it was eliminated from the analysis and the analysis was subsequently rerun to increase the number of subjects included. The final model was based on 168 men with

complete data on all variables. Variables and adjusted odds ratios in the final model are shown in Table 19.

Table 19. Adjusted Odds Ratios and Confidence Intervals From the Backward Stepwise Logistic Regression (Final Model, Men Only)

| Variable | Ranges/ Categories | Adjusted Odds Ratio | 95% Confidence Intervals | Wald Statistic p-value |
|---|---|---|---|---|
| Rank | COL or CAPT[a] | 1.0 | --- | --- |
| | LTC or CDR[b] | 2.8 | 1.2-6.4 | 0.02 |
| Waist Circumference | 28.25-33.75 (in) | 1.0 | --- | --- |
| | 33.76-36.00 | 3.2 | 1.2-8.3 | 0.02 |
| | 36.01-37.75 | 1.3 | 0.5-3.4 | 0.64 |
| | 37.76-42.25 | 2.2 | 0.8-6.3 | 0.13 |
| Bench Press/Body Mass Ratio | 0.627-0.964 (lbs/lbs) | 1.0 | --- | --- |
| | 0.965-1.086 | 2.7 | 1.0-7.4 | 0.06 |
| | 1.087-1.247 | 3.4 | 1.2-9.5 | 0.02 |
| | 1.248-1.919 | 4.0 | 1.4-11.4 | 0.01 |
| Sports Activity in Month Prior to AWC | <1 day/wk | 1.0 | --- | --- |
| | 1-2 days/wk | 0.6 | 0.3-1.3 | 0.17 |
| | 3-4 days/wk | 2.4 | 1.0-6.2 | 0.04 |

[a]LTC= Lieutenant Colonel (Army, Air Force or Marines), CDR=Commander (Navy)
[b]COL=Colonel (Army, Navy or Marines), CAPT=Captain (Navy)

7. HISTORICAL COMPARISONS. One of the goals of this EPICON was to examine whether there was a change in the current (AY00) injury rates compared to that of previous years. For the 3 years where similar data were available (AY92, AY99, and AY00), the injury incidence, injury diagnoses, anatomical location of injuries, injuries prior to the AWC, and activities associated with injuries were compared. Only men were considered in these analyses since only men were analyzed in AY92. If women are included in the comparison of AY00 and AY99, the results are essentially identical to the male-only analysis because of the small number of women.

a. Cumulative Injury Incidence. The cumulative injury incidence in AY00 was lower than that of AY99, but higher than that of AY92. In AY00, the cumulative injury incidence was 45%, while in AY99 (41) it was 57% (p<0.01, risk ratio (AY99/AY00)=1.3, 95%CI=1.1-1.6). The AY00 cumulative injury incidence was higher than the AY92 (84) incidence of 28% (p<0.01, risk ratio (AY00/AY92)=1.3, 95% CI=1.1-1.5).

b. Injuries by Diagnosis. Table 20 compares injuries by diagnoses in AY92, AY99, and AY00. Only diagnoses that were similar in all 3 years were included in this table.

(1) In AY00 and AY99, about 78% of the diagnoses were the same as those in AY92. Diagnoses not listed in the AY92 study were contusions, abrasions/lacerations, degenerative joint disease, retropatellar pain syndrome, stress fractures, and environmental injuries. The AY92 analysis (84) considered only "musculoskeletal injuries". It is likely that degenerative joint disease, retropatellar pain syndrome and stress fractures would have been included among the "musculoskeletal injuries" had these injuries been found in the study. It is also possible that these injuries were recorded under a different diagnosis (e.g., overuse, not otherwise specified) in the AY92 study.

(2) If degenerative joint disease, retropatellar pain syndrome, and stress fractures are included in the analysis, the number of new injury cases in AY99 increases to 143, indicating twice as many injuries occurred in AY99 compared to AY92 (143/72).

(3) If degenerative joint disease is included in the AY00 analysis, the number of new injury cases increases to 117 and there are 1.6 times more injuries in AY00 compared to AY92 (117/72).

(4) In all 3 years, muscle strain is the diagnosis with the largest number of new cases. The proportion of sprains and tendonitis was lower in AY99 and AY00 compared to AY92.

Table 20. Direct Comparison of Injury Diagnoses in AY92 (84), AY99 (41) and AY00

| Diagnoses | AY92 | | AY99 | | AY00 | |
|---|---|---|---|---|---|---|
| | N | Part of Total (%) | N | Part of Total (%) | N | Part of Total (%) |
| Strain | 21 | 29.2 | 48 | 28.6 | 24 | 21.2 |
| Sprain | 15 | 20.8 | 10 | 5.9 | 14 | 12.4 |
| Tendonitis | 12 | 16.7 | 12 | 7.1 | 9 | 8.0 |
| Pain (NOS) | 8 | 11.1 | 16 | 9.5 | 21 | 18.6 |
| Overuse (NOS) | 7 | 9.7 | 18 | 10.7 | 24 | 21.2 |
| Fractures | 4 | 5.5 | 7 | 4.2 | 11 | 9.7 |
| Fasciitis | 2 | 2.8 | 3 | 1.8 | 4 | 3.5 |
| Bursitis | 1 | 1.4 | 6 | 3.6 | 2 | 1.8 |
| Dislocation | 1 | 1.4 | 1 | 0.6 | 0 | 0 |
| Trauma | 1 | 1.4 | 11 | 6.5 | 4 | 3.5 |
| Total | 72 | 100 | 132 | 78.5 | 113 | 77.9 |

c. Injuries by Anatomic Location. The distribution of new injuries by anatomic location is shown in Table 21. In AY92 injuries were evenly distributed between the upper and lower body but in AY99 and AY00 there were more lower body injuries. In AY92 there appears to be a higher proportion of low back and elbow injuries, compared to AY99 and AY00, but a smaller proportion of foot injuries. The distribution of injuries by anatomic location in AY99 and AY00 is similar.

Table 21. Injuries By Anatomic Location in AY92, AY99, and AY00 (Numbers are Percent of Total Injuries)

| Anatomic Location | AY92 | AY99 | AY00 |
|---|---|---|---|
| All Upper Body | 50 | 36 | 43 |
| All Lower Body | 50 | 62 | 54 |
| Low Back | 17 | 10 | 9 |
| Knee | 14 | 17 | 14 |
| Elbow/arm | 13 | 5 | 6 |
| Ankle | 10 | 5 | 8 |
| Shoulder | 8 | 12 | 8 |
| Foot | 4 | 9 | 11 |

d. Prior Injury. In AY99, officers with a prior injury were 1.2 times more likely to experience an injury at the AWC, but this was not statistically significant. This year, officers with a prior injury were 1.4 times more likely to experience another injury at the AWC and this did reach the level of statistical significance ($p<0.03$). In AY99 officers with a prior ankle sprain were more likely to suffer another sprain while at the AWC, but that was not the case in AY00.

e. Activity Associated with Injuries. Table 22 shows a comparison of AY00 and AY99 in terms of injuries and the activities associated with those injuries. In AY92, activities associated with injury were not obtained.

Table 22. Injuries by Activities Associated with Injury (AY99 and AY00)

| Activityı | AY99 | | AY00 | |
|---|---|---|---|---|
| | Injuries (N) | Proportion of Total (%) | Injuries (N) | Proportion of Total (%) |
| Softball | 28 | 17 | 23 | 16 |
| Basketball | 17 | 10 | 12 | 8 |
| Volleyball | 6 | 4 | 4 | 3 |
| Running | 7 | 4 | 7 | 5 |
| Other Sports | 10 | 6 | 15 | 10 |
| Physical Training | 2 | 1 | 4 | 3 |
| Other Activities | 15 | 9 | 21 | 14 |
| Environmental | 4 | 2 | 1 | 1 |
| Unknown | 80 | 47 | 58 | 40 |

[a]From chi-square statistic or Fisher Exact Test

(1) Medical care providers were more likely to include the activity associated with the injury in the medical record in AY00, compared to AY99. In AY00, 60% of the cases had an activity associated with the injury in the medical records, compared to 53% in AY99.

(2) In AY00, softball continued to be the sport with the largest numbers of associated injuries. There was a reduction in the number of softball-associated injuries in AY00 compared to AY99 (Table 22), despite the fact that in AY00 more events were tied to activities in the medical records. Strains

(especially to the hamstrings) and contusions were the major injury types associated with softball in both years.

(3) In AY00, basketball continued to be the sport with the second highest number of associated injuries. There was a reduction in the number of basketball-associated injuries in AY00, compared to AY99 (Table 22). However, the distribution of injuries was considerably different between the 2 years. Last year, the major diagnoses associated with basketball were 7 contusions, 4 strains, and 3 fractures (2 fingers). This year, injuries were more varied and included 3 ankle sprains, 2 strains (shin, neck), 2 fractures (foot, finger), 2 abrasions/lacerations, and 2 overuse injuries (finger, knee). The reasons for this are not clear.

(4) In AY00, there was a small reduction in the number of injuries associated with volleyball compared to last year (Table 22). Despite the small numbers, the injury diagnoses were similar but injury sites differed in the 2 years. Last year, there were 3 strains (2 shoulder, 1 shin) and two ankle sprains. This year there was 1 calf strain, 2 sprains (finger and ankle), and 1 low back pain.

(5) There were more soccer and weight lifting- associated injuries this year than last. In fact, last year only 1 soccer-associated injury was reported and no weight lifting injuries. More officers may have been involved in these activities than in the previous year. Better reporting on the part of the medical care providers may also partly account for this difference.

(6) Overall, there was a decrease in injuries associated with institutionally organized sports (i.e., softball, basketball, and volleyball) in AY00 but an increase in injuries associated with other sports and physical training. There were 51 institutionally organized sport-associated injuries in AY99 and 39 in AY00. Other sports and physical activity-associated injuries were 12 and 19 in AY99 and AY00, respectively.

f. Comparison of HPFA Measures. Table 23 shows a comparison of HPFA measures over the 3 years. Since raw data was available from both AY99 and AY00, independent sample t-tests were run comparing variables in the 2 years. Only students whose medical records were reviewed were considered in these statistical analyses.

(1) There were no differences between the AY99 and AY00 groups on either the initial or final APFT measures.

(2) Compared to AY99, students in AY00 were 1.1% taller and had 2.6% greater body mass. Interestingly, body mass appears to be increasing through all 3 years and the BMI shows this same trend. Compared to AY99, waist circumference was 2.7% greater in AY00; since hip circumference was similar in the 2 years, the waist/hip ratio was 3.1% greater in AY00.

(3) The two estimates of body fat (DEXA was not performed in AY99) provided a somewhat different picture of students in AY00 and AY99. The circumferential body fat estimate showed a non-significant 3.0% greater body fat in the AY00 students; the bioelectrical impedance estimate shows 9.7% more body fat in the AY00 students. When fat free mass was calculated from the circumferential estimate and body mass, there was a 1.8% higher fat free mass in AY00. When fat free mass was calculated from body mass and the bioelectrical impedance estimate of body fat, there was only a 0.4% higher fat free mass in AY00. The overall impression of the AY00 students is that of a taller, heavier group, but it is not clear if this additional weight should be attributed to an increase in body fat or fat free weight.

(4) Students in AY00 scored higher on some strength measures than students in AY99. Bench press and knee extension strength were 18.3% and 9.1% higher, respectively, although there were no differences in knee flexion strength between the two groups. The bench press/body mass ratio was also 15.5% higher in AY00 suggesting greater upper body strength as a proportion of body weight. However, as noted earlier, the starting position for the bench press was higher relative to the chest in AY00 and this could account for the difference between the 2 years.

(5) Among the other HPFA variables, only HDL differed between the 2 years. The AY00 students had 7.7% lower values. This resulted in a 6.4% higher cholesterol/HDL ratio in the AY00 students, since the cholesterol values were similar. HDL has atheroprotective mechanisms (71) and the higher levels in AY00 suggest a lower risk of cardiovascular disease (12).

g. Participation in Sports Activities (AY92 and AY00). There are some data on the proportion of students participating in sport activities in AY00 and AY92, so it is possible to make some comparisons between these 2 years. On the Sport and Exercise Activity Questionnaire used in AY00 (Appendix C), 97% of respondents reported playing softball, 41% played basketball, 66% played volleyball, 100% performed aerobic exercise, and 99% performed strength training. On the Modified Minnesota Leisure Time Physical Activity Questionnaire (MMLTPAQ) (16, 75) administered in AY92 (84), 87% of students reported participation in softball, 75% participated in running, and 71% participated in volleyball. Basketball and weight training were not mentioned in the AY92 report (84).

Table 23. Comparison of AY92, AY99, and AY00 Students on APFT and HPFA Measures (Men Only)

| Measure | AY92[a] (Mean±SD) | AY99[b] (Mean±SD) | AY00 (Mean±SD) | p-value[c] AY00 vs AY99 |
|---|---|---|---|---|
| **APFT Measures** | | | | |
| Initial Push Ups (reps) | DNA[d] | 58±17 | 56±14 | 0.64 |
| Initial Sit Ups (reps) | DNA[d] | 61±16 | 62±13 | 0.51 |
| Initial 2-Mile Run (min) | DNA[d] | 15.4±1.5 | 15.4±1.4 | 0.79 |
| Final Push Ups (reps) | DNA[d] | 57±16 | 57±13 | 0.97 |
| Final Sit Ups (reps) | DNA[d] | 63±15 | 63±14 | 0.83 |
| Final 2-Mile Run (min) | DNA[d] | 15.1±2.1 | 15.4±1.5 | 0.17 |
| **HPFA Measures** | | | | |
| Age (yrs) | 43.5±2.4 | 43.1±2.5 | 43.5±2.8 | 0.14 |
| Stature (cm) | 179.6±6.5 | 178.8±6.6 | 180.6±6.8 | <0.01 |
| Body Mass (kg) | 83.9±9.5 | 85.4±9.5 | 87.5±10.9 | 0.03 |
| Body Mass Index (kg/m$^2$) | 26.0±2.2 | 26.5±2.3 | 26.7±2.4 | 0.46 |
| Waist Circumference (cm) | DNA[d] | 88.9±6.4 | 91.4±6.9 | <0.01 |
| Hip Circumference (cm) | DNA[d] | 101.9±5.3 | 101.6±5.8 | 0.86 |
| Waist/Hip Ratio | DNA[d] | 0.87±0.04 | 0.90±0.05 | <0.01 |
| Body Fat (circumference) (%) | DNA[d] | 20.3±3.5 | 20.9±3.5 | 0.12 |
| Body Fat (impedance) (%) | DNA[d] | 17.6±4.1 | 19.3±4.4 | <0.01 |
| Fat Free Mass (kg)[e] | DNA[d] | 67.9±6.6 | 69.1±7.1 | 0.08 |
| Fat Free Mass (kg)[f] | DNA[d] | 70.1±6.7 | 70.4±7.4 | 0.73 |
| Peak $VO_2$ (ml/kg/min) | 42.4±6.5 | 46.2±6.0 | 45.4±5.7 | 0.17 |
| Maximal Heart Rate (b/min) | DNA[d] | 183±11 | 183±11 | 0.29 |
| Bench Press Strength (kg) | DNA[d] | 82±19 | 97±20 | <0.01 |
| Bench Press/Body Mass Ratio | DNA[d] | 0.97±0.23 | 1.12±0.23 | <0.01 |
| Knee Extension Strength (kg) | DNA[d] | 85±15 | 93±16 | <0.01 |
| Knee Flexion Strength (kg) | DNA[d] | 66±14 | 66±14 | 0.92 |
| Sit and Reach Flexibility (cm) | DNA[d] | 33±9 | 32±9 | 0.19 |
| Resting Heart Rate (b/min) | DNA[d] | 69±11 | 68±11 | 0.49 |
| Systolic Blood Pressure (mmHG) | DNA[d] | 125±14 | 126±12 | 0.11 |
| Diastolic Blood Pressure (mmHG) | DNA[d] | 73±9 | 75±8 | 0.11 |
| Glucose (mg/dl) | DNA[d] | 96±9 | 95±9 | 0.16 |
| Cholesterol (mg/dl) | DNA[d] | 207±33 | 206±35 | 0.82 |
| Triglycerides (mg/dl) | DNA[d] | 130±84 | 131±70 | 0.90 |
| High Density Lipoproteins (mg/dl) | DNA[d] | 49±13 | 45±11 | <0.01 |
| Low Density Lipoproteins (mg/dl) | DNA[d] | 132±31 | 135±34 | 0.43 |
| Cholesterol/HDL[g] ratio | DNA[d] | 4.51±1.35 | 4.83±1.49 | 0.03 |

[a]Data from reference (84)
[b]Data from reference (41)
[c]From independent sample t-test
[d]DNA=Data not available in report
[e]Calculated from body mass and body fat (circumference estimate)
[f]Calculated from body mass and body fat (bioelectrical impedance estimate)
[g]HDL=High density lipoproteins

(1) Caution must be exercised in comparing the AY00 with the AY92 data because of differences in the questionnaires administered and the proportion of students who responded. The MMLTPAQ was a validated and reliable 62+ item questionnaire (16, 17, 75). The questionnaire was provided to students who checked off the activities that they had performed while at the AWC. Then an interview was conducted to obtain more detailed information regarding activity frequency and duration. The questionnaire used in AY00 was very short, targeted toward particular activities, and distributed in the officer's boxes with instructions to return the completed questionnaire. In AY92 it appears that virtually all students completed questionnaires, while in AY00 only 39% of the cohort did so. With these cautions in mind, it appears that there may have been slightly more officers playing softball in AY00, but more officers playing volleyball in AY92.

(2) Another factor to consider when discussing sports participation in AY92 and AY00 is the number of seminar groups in the 2 years. At the AWC, teams for institutionally organized sports are based on seminar groups; that is, a seminar group constitutes a team. Games are played in a round-robin manner such that each team (seminar group) plays all the other teams. In AY92 there were 18 seminar groups and thus 17 games were played. In AY99 and AY00 there were 20 seminar groups and thus 19 games were played (a 11% increase compared to AY92). The literature indicates that less exposure to physical activity results in fewer injuries (15, 34, 46, 50). Further, competitive games against other teams result in a higher injury incidence than practice sessions (4, 21, 26, 52). The additional competitive games played in AY00 may account for a portion of the elevated injury incidence in AY00 (and AY99) compared to AY92.

8. DISCUSSION. The present study found that the cumulative injury incidence among all students (men and women) at the AWC was 44% and the crude injury rate was 6.4 injuries/100 student-months. Where an activity associated with an injury could be found, that activity was a sport in the majority of cases.

a. Change in Injury Incidence, AY99 and AY00. The data show clearly that compared to AY99, AY00 had a lower cumulative injury incidence, a lower injury rate, and fewer new injury cases. However, the reasons for this are not clear. After the AY99 study a number of recommendations were made that focused on injury reduction during sports activities (41). Many of these recommendations were offered too late to be implemented during AY00 since the institutional schedule was well in place by the time the data were fully analyzed.

(1) One possible explanation for the reduction in the injury rate is command emphasis and education and instruction undertaken by the APFRI staff. Based partly on preliminary briefings provided by the CHPPM in May and July 1999, the APFRI staff attempted to reduce injuries in AY00 as follows:

(a) Information on injuries was provided to the students in their "welcome packets" prior to their arrival at the AWC. This information included a short memorandum addressing injury rates and the need to train properly for specific sports. Particular emphasis was placed on warm-up prior to playing softball since this was the sport that students played early in the year.

(b) The need for injury reduction was stressed by both the Commanding General and the Director of the APFRI at the student orientation at the beginning of the academic year. Students were briefed on the high injury rate from the previous year. Injury issues were further addressed with the seminar group leadership and class president at the start of the academic year. APFRI staff emphasized injury reduction throughout the year.

(c) Classes were provided to all seminar groups on aerobic conditioning, strength training, spinal stabilization, and injury prevention during the fall and winter months. About 1/3 of the AY00 class attended special elective courses that covered injury prevention issues.

(d) An attempt was made to have sports representatives complete cards indicating which students attended organized sport activities and who was injured. Compliance was only about 50% so this practice was discontinued. However, this record-keeping may have helped increase student awareness of injuries.

(2) Another possible reason for the lower injury rate in AY00 is physiological differences between students in AY00 and AY99. However, these differences were small and cannot easily account for the differences in injury rates between the 2 years.

(a) There were some small differences among the AY99 and AY00 students in terms of stature, body mass, and possibly body fat. However, neither stature, body mass, nor body fat have consistently been shown to be injury risk factors in this or other studies (33, 42, 44).

(b) AY00 students demonstrated higher bench press and knee extension strength. However, lower strength has not been shown to be an injury risk factor in this or in other investigations (10, 44).

(c) Interestingly, while knee extension strength was higher in AY00 than in AY99, there were no differences in knee flexion strength. At least one study has suggested that an imbalance between the knee flexor and knee extensor muscle groups may predispose to injury. Female athletes with knee flexor/knee extensor (KF/KE) ratios $>0.75$ were 1.6 times more likely to be injured than athletes with ratios $<0.75$ (39). The KF/KE ratios were (mean±SD) $0.79\pm0.15$ and $0.73\pm0.17$ in AY99 and AY00, respectively ($p<0.01$). However, a ratio $>0.75$ was not an injury risk factor in either year (AY00 $p=0.98$; AY99

p=0.61). Differences between the AWC study and the prior study reporting higher injury risk with the KF/KE strength imbalance (39) include the use of different strength testing modes (isokinetic vs isotonic) and different populations. The KF/KE ratio cannot explain the differences in injury incidence in the 2 years in the present study.

(3) Sport and Exercise Activity. Another possible explanation for the lower injury incidence may relate to differences in sports participation among the students in AY99 vs AY00. It has been demonstrated that greater participation in sporting activity increases the risk of injury (15, 34, 46, 50), probably because of greater exposure to injury producing events. No data on sports participation was available in AY99 so it is not possible to directly compare AY99 and AY00 on this basis. However, in AY00 higher sports activity in the month prior to the AWC was an independent injury risk factor. This supports the idea that individuals who played sports before arrival at the AWC were more likely to get injured while at the AWC, possibly because they continued to participate in sports at the AWC and had more exposure to activities with injury potential.

(4) To summarize, increased attention given to the high rate of injuries in AY99 may have had some influence in lowering injury rates in AY99. Physiological differences between the students in AY99 and AY00 were small and unlikely to account for the lower injury rates in AY00. Participation in sports activity in AY99 and AY00 cannot be compared as no data on this factor was obtained in AY99. Sports participation in the month prior to the AWC was an injury risk factor in AY00.

b. Activities Associated with Injuries.

(1) In AY00, 44% of the injuries in the AY99 class were associated with sporting activities. Sports were likely involved in a larger proportion of the injuries since 40% of the injuries did not have an associate event in the medical record. Other studies of military populations where causes of injury have been obtained indicate that sport related activity may account for 19% to 51% of all injuries (41, 47, 76) and 11% of hospitalizations (48).

(2) The recording of activities associated with injuries improved in AY00 compared to AY99. In AY00, activities associated with injury were listed in 60% of injury cases compared to 53% in AY99. However, even in AY00, 40% of medical encounters did not list a proximate event. Continuing emphasis must be placed on recording this type of information in the medical records because proximate events provide a starting point in developing strategies for injury reduction. This is well illustrated in the AWC studies this year and last (41): sports related events seem to have a big role in the genesis of injuries. If proximate events had not been recorded, the role of sports could not be verified.

The proximate event is most easily placed in the subjective portion of the SOAP (subjective, objective, assessment, plan) profile in the medical record.

c. Injury Reduction. Sport related injuries remain an appropriate target for injury-reduction strategies. The injury reduction suggestions provided previously (41) are still viable. The section below repeats many of the previous suggestions (41) but these have been updated to include the more recent information in the literature. Some additional injury reduction strategies are expanded upon, especially in regard to basketball injuries.

(1) Warm-up. Appendix D contains a review of the literature on warm-up and stretching. This review indicated that 6 studies have prospectively examined the influence of warm-up and/or stretching activities on injuries during physical activity. From this review it was concluded that the benefits of warm-up and/or stretching for the reduction of injuries have not been demonstrated but neither practice appears to increase injury rates. Shrier (67) in a recent review came to a similar conclusion on the efficacy of stretching. Warm-up activity may have favorable physiological benefits (Appendix D, paragraph 2) that could possibly reduce injury. Task- specific warm-up activity may be most beneficial because potential physiological benefits may accrue directly to the muscles involved in the activity.

(a) Duplicating the specific activities that a player is likely to perform during practice and competition can create a task specific warm-up program. These activities should be performed slowly at first (low intensity, low force) and the intensity should increase as game time approaches. For example, in volleyball simply practicing sets, spikes, digs, and blocks and increasing intensity can achieve this warm-up. In basketball, players could practice shooting, dribbling, and running, increasing intensity up to game time.

(b) Besides warm-up before play, a secondary warm-up should be conducted when a player has been inactive for a long period. Envisioning the next task the player will perform can help develop appropriate activities. For example, a fielder in softball is likely to perform at least three tasks: running after a ball (ground or fly), catching the ball, and throwing the ball. These activities can be practiced when the player takes the field. Another example is a batter coming to the plate. The batter is likely to perform at least two tasks: swinging at the ball and running the bases. To warm-up, the batter could practice swinging the bat (or bats) and some short sprints or running in place. In volleyball and basketball where the action is relatively continuous, the players should be less susceptible to "cooling down". But, individuals who come into play off the bench could first practice setting and spiking in volleyball; in basketball, running, dribbling, and shooting could be used as warm-up activities.

(2) Emphasis on Injury Reduction and Instruction. As noted above, command emphasis on injury reduction and instruction provided to

students may explain at least a portion of the lower injury rates in AY00. Command emphasis should continue. Classroom instruction should be continued so students have information on injury rates and injury reduction strategies. Correct warm-up procedures (discussed above) and common causes and prevention of sports injuries (discussed below) could be presented. Discussion on secondary prevention could include immediate first aid treatment of an injury (36).

(3) Softball. Softball was the activity associated with the largest number of injuries, 17% and 16% of all injuries in AY99 and AY00, respectively. Although we do not know the mechanism of these injuries, previous literature suggests that over 90% of softball injuries are associated with sliding, catching balls, falling, and collisions with fixed objects and other players (30, 53). In the Army, softball has the third highest rate of hospitalizations for sports related injuries, after basketball and football (48).

(a) Injuries due to sliding into bases can account for 42% to 71% of all softball injuries (30, 53, 83). Sliding injuries occurred 12 times per 1000 slides in one study of Division 1 college teams and rates were almost twice as high for head-first slides compared to feet-first slides (27). Injuries due to sliding can be reduced by allowing overrunning of bases, by using breakaway or compressive bases, and possibly by instruction on proper sliding technique. The overrunning of bases was allowed but not mandated at the AWC in both AY00 and AY99. Guidelines for overrunning should state that players be required to overrun in a straight line and turn to the right. Turning to the right could signal umpires and opposing team players of the runner's intention not to continue on to the next base and end the play. A turn to the left would signal continued play.

(b) If sliding is allowed, sliding injuries can be reduced by the use of breakaway bases. Breakaway bases dislodge from their anchors with a shear force of about 700 foot-pounds, about 20% of the force required to break a standard base (32). In a summer league study at the University of Michigan (Ann Arbor), there were 45 sliding-related injuries (in 627 games) on fields using stationary bases. There were only 2 sliding-related injuries (in 633 games) on fields using breakaway bases (31, 32) (risk ratio (standard base/breakaway base)=22.7).

(c) Compressive bases may also reduce sliding injuries. Compressive bases are constructed to compact inward and downward to absorb the force of a sliding runner (63). A study of league, varsity, and intramural teams in Central Michigan found 3 injuries/100,000 athlete exposures using the compressive bases and 100 injuries/100,000 athlete-exposures using the standard base. However, the absolute number of injuries was extremely small, only 1 using the compressive base and 4 using the standard bases (63). It should also be noted that compressive bases have a long pole that anchors

them to the ground. A pole could serve as a rigid barrier that could cause injury if the force of the slide is very high.

(d) Reminding players to periodically check the field when running after balls may reduce injuries due to collisions with other players. They can also be encouraged to shout their intention to catch a ball so other players in the vicinity (who may also be chasing the ball) can know each others' location. Padding of poles, backstops, field walls, and other objects players are likely to contact may reduce injuries due to collisions with fixed objects. Injuries due to falls may be reduced by proper field maintenance that decreases the number of holes and rough spots in play areas, especially the outfield (31).

(4) Basketball. Basketball was associated with the second highest rate of injuries in this study, 10% and 8% of all injuries in AY99 and AY00, respectively. In the Army, basketball accounts for more sports-related hospitalizations than any other single sport (48). Based on past literature, the most common types of basketball-related injuries are sprains, strains, contusions, and fractures. The most common injury sites are the knee, ankle, and fingers (1, 21, 26, 52, 57, 86). In the present study, the injury types and locations were similar.

(a) Ankle sprains are among the most common single type of basketball injury reported in the literature (26, 57). This is in consonance with the findings in AY00 as there were 3 ankle sprains associated with basketball. High top shoes and semi-rigid ankle stabilizers have been examined as possible methods to reduce ankle sprains.

(b) Studies investigating high top shoes have found that they do not reduce ankle sprains by themselves (6, 18). One investigation showed that taping the ankle in combination with a high top shoe did reduce ankle sprains (18) in individuals playing basketball but these results have not been duplicated in soccer or football players (58, 65). Thus, injury control through the use high top shoes or high top shoes in combination with taping has not been firmly demonstrated at this point. Also, consideration must be given to the cost, amount of time involved in taping, and the low number of cases at the AWC.

(c) On the other hand, a prospective study showed that the use of a semi-rigid ankle stabilizer (Aircast Sports Stirrup, Aircast, Inc., Summit NJ) reduced the incidence of acute ankle sprains among basketball players (69). One prospective and two retrospective studies using soft lace-up ankle braces or the Aircast Sports Stirrup have also shown significant reductions the recurrence of ankle sprains in soccer players and football players (58, 65, 74). Thus, the use of a semi-rigid brace should be encouraged, especially among those with prior ankle sprains.

(d) One study developed an equation that predicted risk of basketball injury with an overall accuracy of 91%. The three factors in the predictive equation were weight imbalance (i.e., a difference in body weight supported by the right and left leg, possibly reflecting leg length differences), abnormal right Q-angle, and abnormal left Q-angle (64). However, an independent follow-up study using a separate sample of basketball players found only 5% of injuries were correctly predicted by using this equation (23).

(5) Volleyball. Volleyball was associated with 4% of injuries in AY99 and 3% of injuries in AY00. There were 2 ankle sprains in AY99 and 1 in AY00. The literature indicates that ankle sprains are one of the most common types of volleyball injuries accounting for 16% to 50% of all injuries in this sport (19, 62, 81). Ankle sprains often occur when a blocker returns to the ground and lands on the foot of a spiker (4, 61, 62, 81). Other blocking and spiking activities also appear to generate a variety of injuries. During the spike, the blocker or blockers jump upward with arms elevated and fingers spread wide. Because of the speed and force of the spike, blockers can experience sprain and dislocation injuries of the interphalangeal and metacarpalphalangeal joints, fractures of the phalanges, and lacerations of the web spaces from abduction injuries (4, 19, 62). Serving, passing, setting, and digging have not been associated with a high rate of injuries (9, 19, 61).

(a) Volleyball injuries may be reduced by modification of the rules, training on blocking and spiking techniques, reducing practice time, and by playing on wooden floors. A rule change that prohibits contact with the centerline at any time may reduce ankle injuries because it would reduce the likelihood of blocker/spiker foot contact (4, 61). One study showed that the incidence of ankle sprains was reduced from 0.9/1000 player-hours (48 injuries) to 0.5/1000 player-hours (24 injuries) following a program that involved injury awareness training, technical training on proper take-off and landing technique for blocking and spiking, and balance board training for players with recurrent ankle sprains (3). Another study showed that the incidence of patellar or quadriceps tendonitis increased linearly as the number of weekly volleyball training sessions increased (15). Athletes who played on cement or linoleum floors had five to eight times higher injury risk than athletes who played on parquet (wooden) floors (15). The surface played on by AWC students is of the latter type.

(b) As noted above in the section on basketball, ankle sprains may be reduced by the use of semi-rigid ankle stabilizers. However, this intervention has not been specifically tested among volleyball players.

c. Injury Risk Factors. In AY00, independent risk factors for injuries at the AWC included, rank, bench press/body mass ratio, waist circumference, and previous sports activity. In AY99, independent risk factors for injuries at the AWC included higher peak $VO_2$, higher resting systolic blood pressure, and

several variables from the Health Risk Appraisal. None of the significant risk factors identified in AY99 were duplicated in AY00. The lack of concurrence between the 2 years casts doubt on the reliability of these associations.

d. Prior Injury. In AY00 a prior injury of any type was more likely to result in another injury at the AWC. In AY99 there was a non-significant trend in this same direction: 60% of officers with prior injury were again injured at the AWC as opposed to 52% of officers without prior injury who were injured at the AWC. No single type of injury could account for the higher risk among previously injured officers in AY00.

(1) In AY99 students that had an ankle sprain in the 5 years prior to the AWC were more likely to have another sprain. This finding was not duplicated in AY00. It should be noted that although the AY99 finding was in consonance with other studies of ankle sprains in the literature (13, 35), it was based on very few (n=3) prior ankle sprain cases.

(2) Further work on prior ankle sprains should include an examination of sprains in periods farther back than 5 years. Also, the use of a semirigid ankle brace should still be encouraged among those with prior ankle sprains because the literature supports the fact that it prevents ankle sprain recurrences (58, 65, 74).

9. Recommendations

(a) Perform a task specific warm-up before all sports activity. This warm-up should duplicate the activities performed in the sport. This warm-up should start slowly (low intensity, low force) and build to a higher intensity over time. Perform a task specific warm-up when activity has ceased long enough to reduce body temperature (e.g., coming off the bench in volleyball or basketball) or for activity that is performed intermittently (e.g., batting or fielding activities in softball). This warm-up should again duplicate the activities in the sport.

(b) Continue command emphasis on injury reduction. Continue to provide classroom instruction to students to inform them of injury rates, common causes of sports injuries, correct warm-up procedures, and what to do when an injury occurs (to speed rehabilitation).

(c) Continue to emphasize the practice of allowing the overrunning of second and third base in softball. If sliding is allowed, use breakaway (Rogers Break-Away base, Elizabethtown PA) or compressive (Hollywood Bases Inc., Marysville CA) bases. Encourage players to periodically check the field when running after balls and shouting their intention to catch a ball so other players in the area know of their location. Assure there is proper padding of poles, backstops, field walls, and other objects players are likely to contact. Assure that

softball fields are maintained to reduce the number of holes and rough spots in play areas.

(d) Encourage the use of semi-rigid ankle braces to prevent ankle sprains, especially among those students that have had prior ankle sprains.

(e) To reduce volleyball injuries, institute a rule change that prohibits contact with the centerline at any time, especially after the spike and block. Provide training on blocking and spiking techniques. Assure volleyball continues to be played on wooden floors rather than concrete or linoleum.

(f) Reduce the number of practice and game sessions since reducing activity exposure may reduce injury incidence.

(g) Continue to emphasize that medical care providers question students about what they were doing at the time of the injury. Providers should record this information in the "subjective" part of the medical record SOAP note.

10. Conclusions. The injury incidence in AY00 was 23% lower than in AY99. Although the reasons for this are not clear, possible explanations include an increased command emphasis on injury reduction, education of students on injury prevention techniques, and increased visibility regarding injury control measures during the academic year. Sport related events still account for much of the activity associated with injury and thus remain an appropriate target for intervention. Emphasis should continue on injury reduction in AY01 using the recommendations provided in this report.

## APPENDIX A

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## APPENDIX B

### Physical Activity Questionnaire (AWC, AY00)

Name: ________________________ SSAN: __________________ Box No. ________
(Last, First, Middle)

**On the following questions, rate how often you exercised on average IN THE MONTH PRIOR TO YOUR ARRIVAL at the Army War College (AWC)**

1. AEROBIC EXERCISE: How many days per week did you perform aerobic exercise (running, cycling, swimming, etc) for at least 20 minutes in the last month?

___ None
___ Less than 1
___ 1-2 days/wk
___ 3-4 days/wk
___ 5-6 days/wk
___ 7 days/wk

2. STRENGTH TRAINING: How many days per week did you do exercise to improve your strength (free weights, universal, nautilus, push-ups, sit-ups, etc.) for 20 minutes or more in the last month?

___ None
___ Less than 1
___ 1-2 days/wk
___ 3-4 days/wk
___ 5-6 days/wk
___ 7 days/wk

3. SPORTS ACTIVITY: How days per week did you participate in sports for 15 minutes or more in the last month?

___ None
___ Less than 1
___ 1-2 days/wk
___ 3 - 4 days/wk
___ 5-6 days/wk
___ 7 days/wk

4. WALKING OR HIKING: How days per week did you walk or hike for exercise in the last month?

___ None
___ Less than 1
___ 1-2 days/wk
___ 3-4 days/wk
___ 5-6 days/wk
___ 7 days/wk

5. OVERALL PHYSICAL ACTIVITY. Overall, how would you rate yourself as to the amount of physical activity you perform, compared to others of your age and sex?

___ Much more active
___ Somewhat more active
___ About the same
___ Somewhat less active
___ Much less active

Comments ______________________________________________

APPENDIX C

## Sports and Exercise Activity While at the AWC (AY00)

Name: ________________________ SSAN: __________________ Box No. ________
(Last, First, Middle)

**1. On the questions below, list the approximate proportion of time you spent in each of these sports during organized seminar group practice and competition while at Carlisle Barracks.**

a. Softball

_____ Did not participate
_____ 1% to 24% of practices and games
_____ 25% to 49% of practices and games
_____50% to 74% of practices and games
_____ 75% to 95% of practices and games
_____ 96% to100% of practices and games

b. Basketball

_____ Did not participate
_____ 1% to 24% of practices and games
_____ 25% to 49% of practices and games
_____50% to 74% of practices and games
_____ 75% to 95% of practices and games
_____ 96% to100% of practices and games

c. Volleyball

_____ Did not participate
_____ 1% to 24% of practices and games
_____ 25% to 49% of practices and games
_____50% to 74% of practices and games
_____ 75% to 95% of practices and games
_____ 96% to100% of practices and games

**2. On the following questions, check how often you performed each activity on average while you were at Carlisle Barracks**

a. AEROBIC EXERCISE(running, cycling, swimming, etc) for 20 minutes or more

___ None
___ Less than 1 day per week
___ 1-2 days per week
___ 3-4 days per week
___ 5-6 days per week
___ 7 days per week

b. STRENGTH TRAINING (free weights, universal, nautilus, push-ups, sit-ups, etc.) for 20 minutes or more

___ None
___ Less than 1 day per week
___ 1-2 days per week
___ 3-4 days per week
___ 5-6 days per week
___ 7 days per week

Comments ________________________________________________________________

# APPENDIX D

## A Review of the Literature on Warm-up and Stretching in Relation to Injuries

It is often assumed that warm-up and stretching procedures before physical activity can reduce injuries. The purpose of this Appendix is to define warm-up and stretching then review the few studies that have specifically examined the influence of warm-up and stretching on the likelihood of injury.

Warm-up can be defined as actions that attempt to increase body temperature by active or passive means before or during participation in sports or exercise. Passive warm-up includes the use of such external devices as hot showers, steam baths, or massage. Active warm-up involves volitional body movements using calesthenitics, jogging, stretching, or resistive exercises. A subcategory of active warm-up is task-specific warm-up which concentrates on movements through ranges of motion that will be used in a specific sport or physical activity (60, 66, 70)

Warm-up results in several favorable physiological changes. An increase in body temperature is the major effect. This results in increased speed and force of muscular contractions, increased blood flow, a more rapid dissociation of oxygen from hemoglobin and myoglobin, a more rapid mobilization of energy substrates, reduced muscle viscosity, and increased speed of neural impulses (59, 66). Warm-up may also result in some increase in flexibility in the joints involved in the movements (72) and reduction in the probability of myocardial ischaemia (5).

Stretching can be defined as activity designed to increase the flexibility (range of motion) around a joint. Ballistic stretching uses a series of quick, jerky movements concentrating at the extremes of the joint range of motion. Static stretching involves moving to the extreme of the joint range of motion and holding there for a period of time. Contract-relax stretching involves moving to the extreme of the joint range of motion, actively contracting the muscles around the joint, then relaxing; this is repeated several times with the joint range of motion increasing slightly each time (66, 70). Stretching can be used as a form of active warm-up.

The physiological basis of stretching to achieve increased flexibility is less sound than that of warm-up. Flexibility profiles differ considerably in different sports suggesting different amounts of flexibility are favored in different sports (20). In some sports like running, individuals with less flexibility in certain muscle groups actually run more economically (11, 20). Maximal voluntary strength can be reduced with stretching (45). Some epidemiological data indicate that extremes of flexibility (too much or too little) may not be desirable: studies on basic trainees (35, 44) and collegiate athletes (43) have shown that both high and low levels of flexibility are associated with increased risk of injury. Epidemiological studies of injuries in runners and rowers found either that there

was no difference in the likelihood of injury between those who stretched and those who did not (49, 79) or that risk of injury was elevated among those who stretched (29, 79).

Six experimental (clinical) studies have been conducted to examine the effects of stretching or combined stretching and warm-up on injury prevention (8, 14, 25, 55, 56, 77). A summary of these studies is presented in the table in this Appendix. The study of soccer players by Ekstrand et al. (14) involved many more interventions than just a simple warm-up/stretching routine. It is not possible to separate the effects of warm-up and/or stretching from the influences of the other interventions. The study by VanMechelen et al. (77) was a well-randomized control trial of warm-up/stretching before and after running exercise. No difference was found in injury incidence between the intervention and control groups.

The study by Bixler and Jones (8) involved five football teams. Three of the teams were requested to warm-up and stretch just before the end of half-time; and the remaining two teams did not warm-up or stretch.. The teams were not assigned to treatments on a random basis; rather, the intervention teams were selected on the basis of which would most likely follow the warm-up and stretching protocols. When protocols were not followed, injuries occurring in those games were grouped with the control (non-intervention) data. There were no significant differences between the intervention and control data for number of injuries per game, number of third quarter injuries per game, or number of strain/sprains per game. However, the number of third quarter stains/sprains per game was reduced in the intervention group.

The study by Hartig and Henderson (25) involved only a simple hamstring stretching routine performed 2-3 times per day. The group that stretched had fewer lower extremity overuse injuries compared to the group that did not stretch. Like the previous study, this investigation was not randomized; rather, it was conducted in two separate companies of infantry basic trainees, one company performing the intervention and the other serving as the control. Injury incidence can vary two-fold in different basic training companies (44), at least partially because of training differences (34).

The two studies by Pope and co-workers (55, 56) had randomized designs, large sample sizes, and well-defined injury cases. The latter study (56) controlled for physical fitness, weight, height, body mass index, and age in a multivariate analysis. Assigning a single instructor to both the control and intervention groups controlled potential differences in instruction. Both studies indicate that stretching prior to exercise did not reduce injury risk.

## Appendix D Table. Studies Examining the Effects of Warm-up and Stretching on Injuries

| Study | Sample / Length of Study | Intervention (s) | Groups | Findings |
|---|---|---|---|---|
| Ekstrand 14 | Soccer Players / 6 months | Warm-up (20 min)<br>10 min specific warm-up (ball kicking)<br>10 min contract-relax stretching<br>Cool down (5 min)<br>Shin guards<br>Ankle taping of previous ankle sprains or instability<br>Special rehabilitation program<br>Exclusion of players with knee instability<br>Information on injuries<br>Supervision of program | 1. Control<br>2. Stretching | 1. Control – 93 injuries / 90 players<br>2. Stretching – 23 injuries / 90 players. |
| Van Mechelen et al. 77 | Runners / 16 Weeks | Warm-up (20 min)<br>6 min of running<br>3 min of "loosening" exercises<br>10 min of static stretching<br>3 bouts of 10 sec, with each muscle group<br>muscle groups included iliopsoas, quadriceps, hamstring, soleus, gastronemius<br>Cool-down – inverse of warm-up<br>(Stretching performed twice each day) | 1. Control<br>2. Stretching | 1. Control – 20 injuries / 167 runners<br>2. Stretching – 24 injuries / 159 runners |
| Bixler and Jones (8) | 5 high-school football teams | Warm-up and stretching at end of half time break.<br>Warm-up: run in place (60 sec), jumping jacks (30 sec)<br>Stretching: trunk twist (15-sec), hamstring stretch (25 sec), groin stretch (25 sec), quad stretch (25 sec) | 1. Two control football teams<br>2. Three football teams that stretched | 1. Control – 2.4 injuries/game; 0.46 3d quarter sprains/strain per game<br>2. Stretching – 2.4 injuries/game; 0.04 3d quarter strains/sprains per game |
| Hartig and Henderson 25 | Male Infantry Basic Trainees / 13 weeks | Hamstring stretches<br>3 times/day<br>5, 30 sec static stretches each time, each leg | 1. Control – Single company of trainees<br>2. Stretching – single company of trainees | 1. Control – 43 injuries / 148 trainees<br>2. Stretching – 25 injuries / 150 trainees |
| Pope et. Al. (55) | Male Australian Army Recruits / 12 weeks | Two 20-sec stretches of two muscle groups (gastronemius and soleus) prior to exercise | 1. Control (no stretching but performed 3 min warm-up)<br>2. Stretching and 3 min warm-up | 1. Control – 25 injuries<br>2. Stretching – 23 injuries |
| Pope et Al. (56) | Male Australian Army Recruits / 12 weeks | One 20-sec pre-exercise stretch of each of 6 muscle groups (gastrocnemis, soleus, hamstrings, quadriceps, hip adductors, and hip flexors) prior to exercise | 1. Control (no stretching but performed 4 min warm-up)<br>2. Stetching and 4 min warm-up | 1. Control – 5.4 injuries/1000hrs training<br>2. Stretching – 5.3 injuries/1000hrs training |

Several studies have been conducted on isolated rabbit muscle that suggests that the warm-up temperature achieved in the muscle should not be excessive. Safran et al. (59) "pretreated" isolated rabbit muscles with a

single, electrically induced, 15-sec isometric contraction. Muscle temperature was increased 1°C as a result of this pretreatment. Compared to muscles that had not received this treatment, the pretreated muscles required more force to tear and achieved a greater length prior to tearing. This suggests a moderate increase in muscle temperature may reduce strain-type injuries. Other studies show less favorable effects when muscle temperatures become excessive. Strickler et al (73) compared an isolated rabbit muscle tested at 25°C to one tested at 39°C. They found that the heated muscle required less force to rupture but achieved greater length prior to rupture. Noonan et al. (54) performed a similar experiment, comparing rabbit muscle at 25°C to one at 40°C. In all cases, the heated muscle required less force to rupture. At faster pulling speeds (10 cm/sec) the heated muscle achieved a greater length before failure, while at slower pulling speeds (1 cm/sec) there was no difference between the hotter and cooler muscle.

Thus, the literature concerning warm-up suggests that activities that do not raise muscle temperature too high may have favorable physiological effects. However, the influence of warm-up exercise *per se* on injury rate has not been determined. Stretching reduces maximal strength and when used as a means of increasing flexibility may have different effects depending on the type of physical activity to be performed. Further, individuals with both high and low levels of flexibility appear to be at greater risk of injury. The effects of stretching exercises *per se* on injury rate have not been clearly demonstrated and most well randomized studies suggest that stretching does not reduce injury rates.

# APPENDIX F

## ACKNOWLEDGMENTS

For their assistance and support, we would like to thank the staffs of the U.S. Army Physical Research Institute (APFRI), Dunham Army Health Clinic (DAHC), Army War College Student Operations (AWCSO), and the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM).

From APFRI, we thank COL William F. Barko for his advocacy and advice. Royce Sheldon cheerfully and fully answered our questions on the Health and Physical Fitness and the Health Risk Appraisal databases. LTC Mark Vaitkus helped clarify the current methods and instruments used for the Health and Physical Fitness Assessment. MAJ Diane D. Scherr, CPT Lori D. Hennessy, and Melanie T. Richardson graciously answered our questions on the students and the AWC environment and helped us interpret some of the findings.

Individuals at DAHC in the Medical Records Section who provided us medical records and answered our many questions included Wahnettah A. Harvey, Jody L. Hoover, Betty J. Kress, Bruce E. Stahl, Andrea M. Lehman, and Gary L. Feathers. DAHC provided facilities for screening the records and the individuals that made our screening days go easier included MAJ Roderick Frazier, SSG Tina Pirofsky, Ann Rigali, Dr. Richard Lucidi, Debbie Beam, Mary Ann Engelman, SGT Curry, CPL Marsalis and Shirley McIntire. The support of COL Stevens Gibbs, commander of DAHC, was also gratefully appreciated.

AWCSO provided us with information and databases and we are grateful to Celinda K. Davis for these.

From the USACHPPM, Carol Pace prepared the final copy of the manuscript for printing and publication.